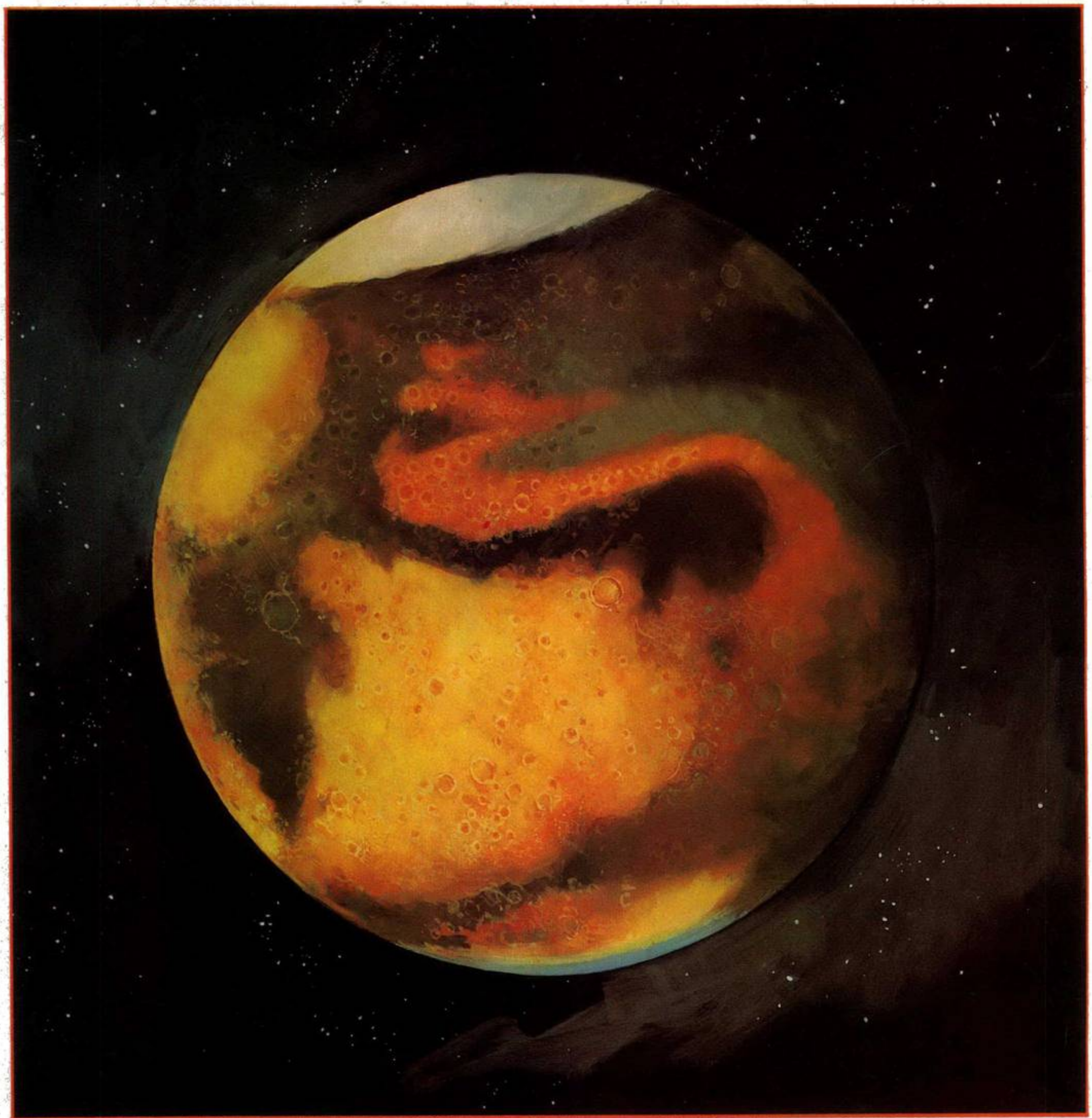
ASTRONOMY

July 1981
$2
UK 95p

Viking: 5 Years on the Red Planet

Come Explore a Comet

July's Lunar and Solar Eclipses



Mars

Meade System 2000

Think of the dimensions a truly research-quality instrument would add to your observing program.

Then consider moving up to the quality and performance of a Meade 4-inch or 8-inch Schmidt-Cassegrain. For Meade Schmidt-Cassegrains, both optically and mechanically, really are the finest instruments of their kind ever offered the serious observer and astrophotographer.

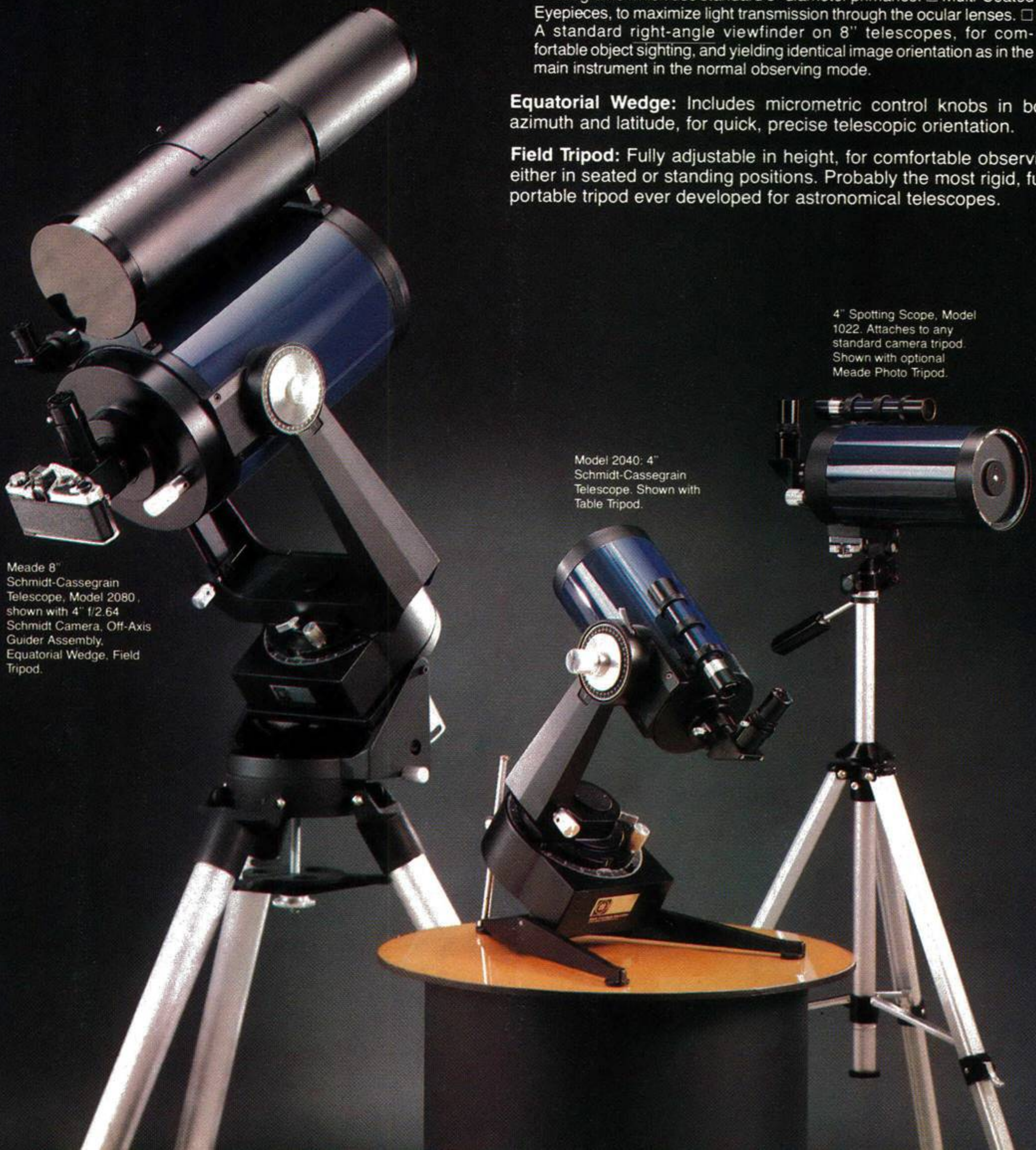
And, as parts of a wide-ranging system, they are instruments that will grow with your expanding horizons.

Standard Equipment: No other commercially available Schmidt-Cassegrains offer such a list of important technical advantages, much less as standard equipment included in the Base Price:

Worm gear drive systems, on both 4" and 8" models, for extremely low photo-visual periodic error and zero backlash. ☐ Ball bearings on both Declination and Polar Axes, permitting microsmooth tracking and precise balancing, even with the addition of auxiliary systems on the main telescope. ☐ On 8" models, an oversize 8.25" primary mirror, for a wider fully illuminated field, and to reduce the "edge darkening" of Schmidt-Cassegrains which use standard 8" diameter primaries. ☐ Multi-Coated Eyepieces, to maximize light transmission through the ocular lenses. ☐ A standard right-angle viewfinder on 8" telescopes, for comfortable object sighting, and yielding identical image orientation as in the main instrument in the normal observing mode.

Equatorial Wedge: Includes micrometric control knobs in both azimuth and latitude, for quick, precise telescopic orientation.

Field Tripod: Fully adjustable in height, for comfortable observing either in seated or standing positions. Probably the most rigid, fully portable tripod ever developed for astronomical telescopes.



4" Spotting Scope, Model 1022. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.

Model 2040: 4" Schmidt-Cassegrain Telescope. Shown with Table Tripod.

Meade 8" Schmidt-Cassegrain Telescope, Model 2080, shown with 4" f/2.64 Schmidt Camera, Off-Axis Guider Assembly, Equatorial Wedge, Field Tripod.

Schmidt-Cassegrains

The System: Perhaps most importantly of all, Meade System 2000 Schmidt-Cassegrains are part of a wide and versatile system: the amazing 4" f/2.64 Schmidt Camera; 4" Schmidt-Cassegrain Photo-Guide Telescope with Illuminated Reticle Eyepiece; Dual-Axis Drive Corrector, and more — all of which attach easily and directly to 8" models.

Aesthetic Design: In the beauty of their enameled deep-blue tube surfaces, in the fineness of their machine-tooled mechanical components, Meade System 2000 models are light years ahead of the competition. See the System 2000 for yourself, and no further explanation will be necessary.

Warranty: As with all Meade products, the System 2000 is fully covered by the Meade One-Year Limited Warranty. See the Meade catalog for full details on this no-risk protection of your investment.

PRICE LIST

Model 2040:	
4" Schmidt-Cassegrain Telescope with Fork Mount ......Base Price	**$595**
Model 2080:	
8" Schmidt-Cassegrain Telescope with Fork Mount ......Base Price	**865**
Equatorial Wedge 4"/8"	**60**
Field Tripod 4"/8"	**160**
Table Tripod 4"	**40**
Table Tripod 8"	**50**
Model 1020: 1000mm f/10 Telephoto Lens	**325**
Model 1022: 4" Spotting Scope	**395**
Meade Photo Tripod for Models 1020 or 1022	**50**
Model 2066: 4" f/2.64 Schmidt Camera	**435**

All prices include packing. Complete telescopes are packed in luggage-quality foam-lined carrying cases. All prices F.O.B. Costa Mesa, California. Calif. residents add 6% sales tax.

Catalog: Send $3.00 (Outside North America $5.00 for air mail) for your copy of the new 52-page Meade Color Catalog **No. 81-C**, with full details on Meade Schmidt-Cassegrains, Newtonian reflectors, refractors, accessories.

Orders: May be placed by mail, or by telephone at **(714) 556-2291**, or visit our Costa Mesa factory/showroom.

Meade Instruments Corporation
1675 Toronto Way, Costa Mesa, California 92626

A partial listing of optional accessories for the System 2000 (see below) includes: ☐ Telecompressor (Multi-Coated) ☐ 2x Telenegative Amplifier ☐ Illuminated Reticle Guiding Eyepiece ☐ Erecting Prism ☐ 8 x 50mm Right-Angle Viewfinder ☐ Tele-Extender ☐ T-Adapter ☐ Off-Axis Guider ☐ 2" Diagonal ☐ 2" O.D. Wide-Angle Erfle 32mm Eyepiece ☐ Series 2 Orthoscopic and Modified Achromatic Eyepieces ☐ Research Grade Eyepieces ☐ Photo-Visual Color Filters (.965" and 1¼").

Note: See Meade Catalog for detailed specifications and standard-accessories listings of telescope models shown.

Model 2080: 8" Schmidt-Cassegrain Telescope, with Table Tripod, 4" Photo-Guide Telescope, Illuminated Reticle Eyepiece.

4" Schmidt-Cassegrain, Model 2040, with Equatorial Wedge and Field Tripod.

Model 1020: 1000mm f/10 Telephoto Lens. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.

ASTRONOMY

Vol. 9, No. 7 July 1981

The World's Most Beautiful Astronomy Magazine ● Established by Stephen A. Walther

Editor
Richard Berry
Managing Editor
Katherine King
Associate Editor
Robert Burnham
Associate Editor
Dewey Schwartzenburg
Copy Editor
Ross Parker Simons
Art Director
Thomas L. Hunt
Art Assistants
Jane K. Borth
Mary MacAdam
Editorial Assistants
Dianne Precourt Cuneo
Mari Wing

President, AstroMedia Corp.
Robert A. Maas
Advertising Coordinator
Mary Kuklinski
Comptroller
Dennis K. Wilk
Circulation Manager
Rosemary L. Pickart

Film Production
Driscoll:Graphics Co.
Printer
E.F. Schmidt Co.
U.S. Newsstand Distribution
Eastern News Distributors
111 Eighth Ave.
New York, NY 10011
Canadian Newsstand Dist.
Distr. Div. of TV GUIDE
112 Merton St.
Toronto, Ontario M4S 2Z7
World Newsstand Distribution
Boaris International
747 Third Ave.
New York, NY 10017

6 Mars: 5 Years after Viking

18 Gravity Lenses: A Focus on the Cosmic Twins
by Emilio Falco and Nathaniel Cohen

Forum 24 Come Explore a Comet
Bruce Murray on the Future of America in Space

Eye on the Sky 30 The Great Conjunction: Act III
by Fred Schaaf

In Focus 36

Behind the Scenes 37

Equipment Atlas 38 The Electronic Sky
by Ben Mayer

Gazer's Gazette 47 July's Lunar and Solar Eclipses

AstroNews 56

Astronomy Reviews 62

Stellar Frontiers 66 The Age of the Universe
by Barry Parker

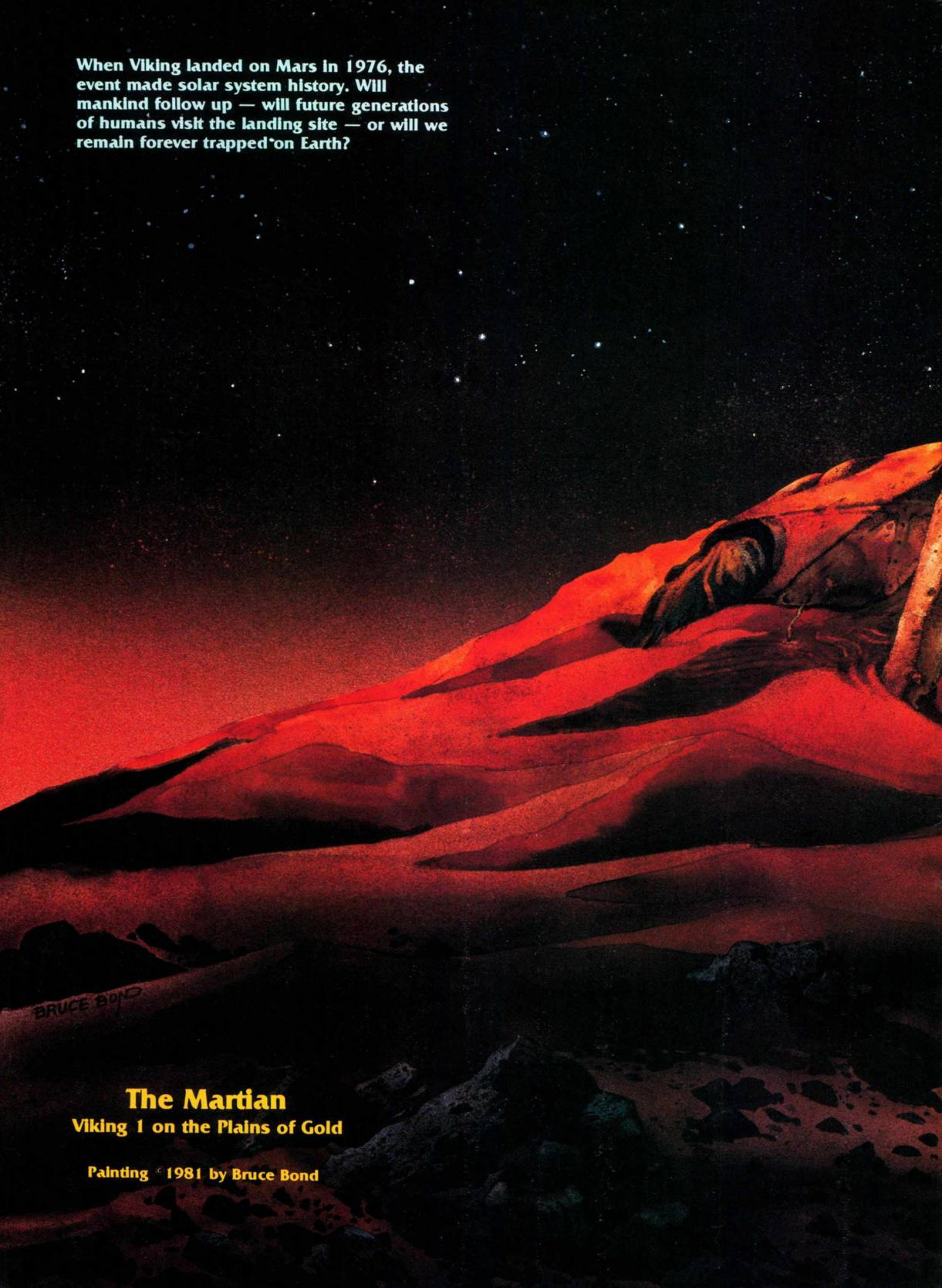
AstroMart 72

Through the Eyepiece 78 Close-up on Ophiuchus

Cover: Five years ago this month, the first Viking Lander began a series of experiments on the surface of Mars to determine whether the Red Planet might harbor living material. Though we did not find life, the data retrieved by the Viking series have helped us to a greater understanding of another world. This issue of ASTRONOMY salutes the scientists, engineers, and technicians who conceived of, built, and operated the Viking mission. Cover painting by Barbara Ericksen; these pages by the Viking 2 Lander on the Utopia Plains of Mars.

ASTRONOMY (ISSN 0091-6358) is published monthly by AstroMedia Corp., 411 E. Mason St., P.O. Box 92788, Milwaukee, WI 53202. Telephone: (414) 276-2689. Copyright © 1981 AstroMedia Corp., all rights reserved. Material in this publication may not be reproduced in any form without permission. Controlled circulation postage paid at Milwaukee, WI and at New York, NY. POSTMASTER: Send address changes to ASTRONOMY, P.O. Box 92788, Milwaukee, WI 53202. Send editorial inquiries and submissions to the address above. Not responsible for unsolicited materials. Questions about subscriptions and product orders: (414) 276-2689 weekdays, 8am - 4pm. Allow six to eight weeks for new subscriptions and changes of address. New subscriptions start with current issue. Subscription price: 1 year, $18.00. All foreign: add $5.00 per year; please remit in U.S. funds. AstroMedia staff: Teresa Banks, Jacquelyn Berger, Stephanie Kiel, Clarita Manio, Maggie Martinez, Bruce Precourt, Susan Robinson. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature*. Microfilms of ASTRONOMY available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 44691. Printed in the U.S.A.

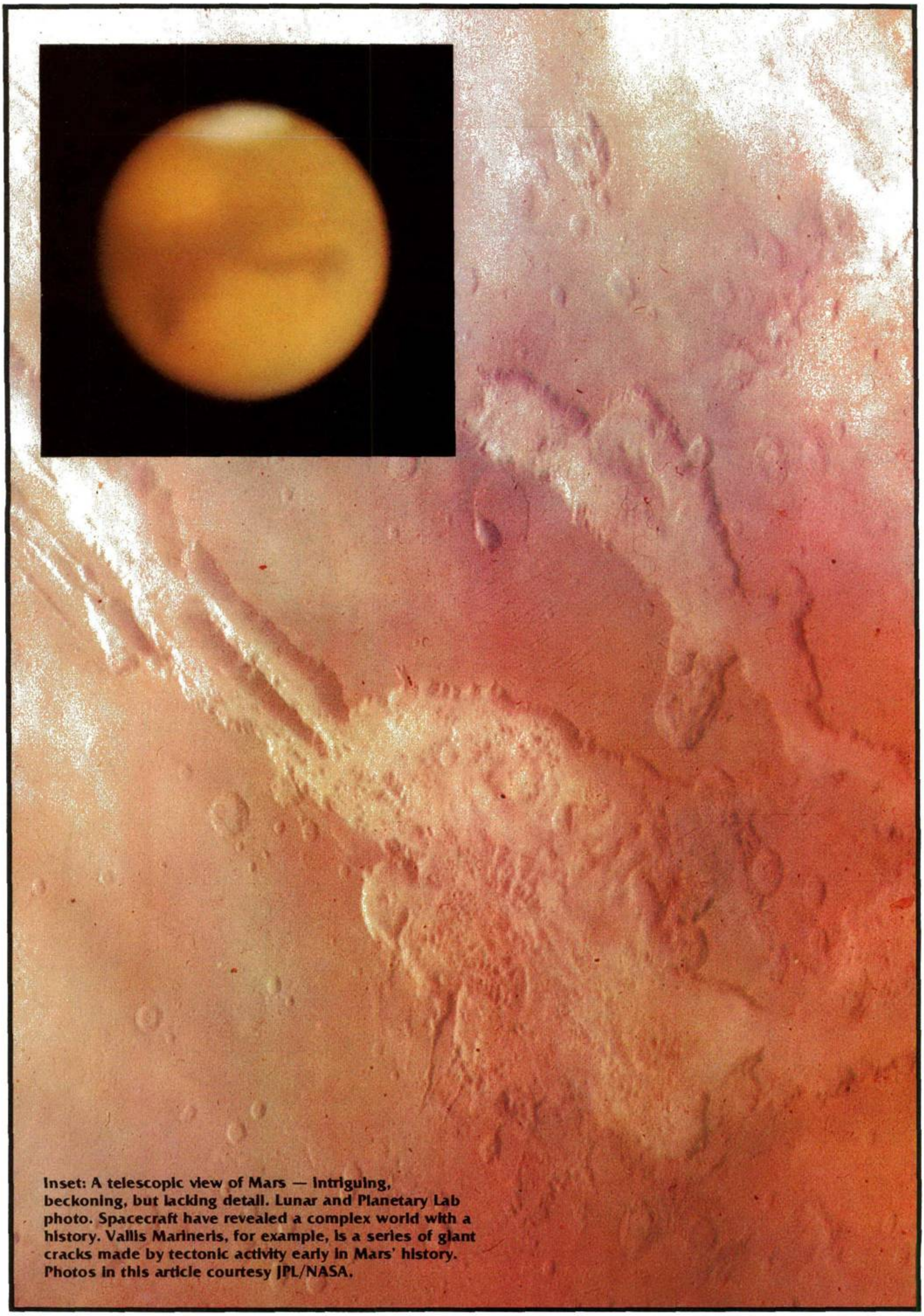
When Viking landed on Mars in 1976, the event made solar system history. Will mankind follow up — will future generations of humans visit the landing site — or will we remain forever trapped on Earth?



The Martian

Viking 1 on the Plains of Gold

Painting ©1981 by Bruce Bond



Inset: A telescopic view of Mars — intriguing, beckoning, but lacking detail. Lunar and Planetary Lab photo. Spacecraft have revealed a complex world with a history. Vallis Marineris, for example, is a series of giant cracks made by tectonic activity early in Mars' history. Photos in this article courtesy JPL/NASA.

Mars 5 years after

Even when viewed in Earth-based telescopes, Mars appears to be an active planet. From a distance of 56 million kilometers, its generally orange-yellow face shows broad gray-green markings that vary from year to year, bright white polar caps that wax and wane with the martian seasons, white clouds and yellow dust storms that blanket the planet from time to time. But observing from Earth is frustrating. Mars is far away and small. Under the best conditions, even at the time of closest opposition, even under the clearest and steadiest skies on Earth, the tiniest features that the keenest visual observers can see are about 60 kilometers across.

The great observers of the past saw tantalizing glimpses: hints of great linear markings, strange clouds, a "wave of darkening" in the martian spring, dust storms that spread over a hemisphere in days; and perhaps, in moments of extraordinary seeing, hints of the craters and volcanos. Three centuries of telescopic observing provided some insight into the nature of the red planet — but not enough.

When the first spacecraft left for Mars, the planet was known to have a thin atmosphere, approximately one-tenth as dense as Earth's. Mars was regarded as possibly Earth-like — but less developed. That Mars is cold and dry, though perhaps not too dry for life, had been established; and it was suspected of having high winds. The existence of the "canals" — however popular the idea was with the public — had long since been discounted by astronomers. But little was known about Mars, so it still held a tantalizing dream: the possibility of other life-forms in our solar system.

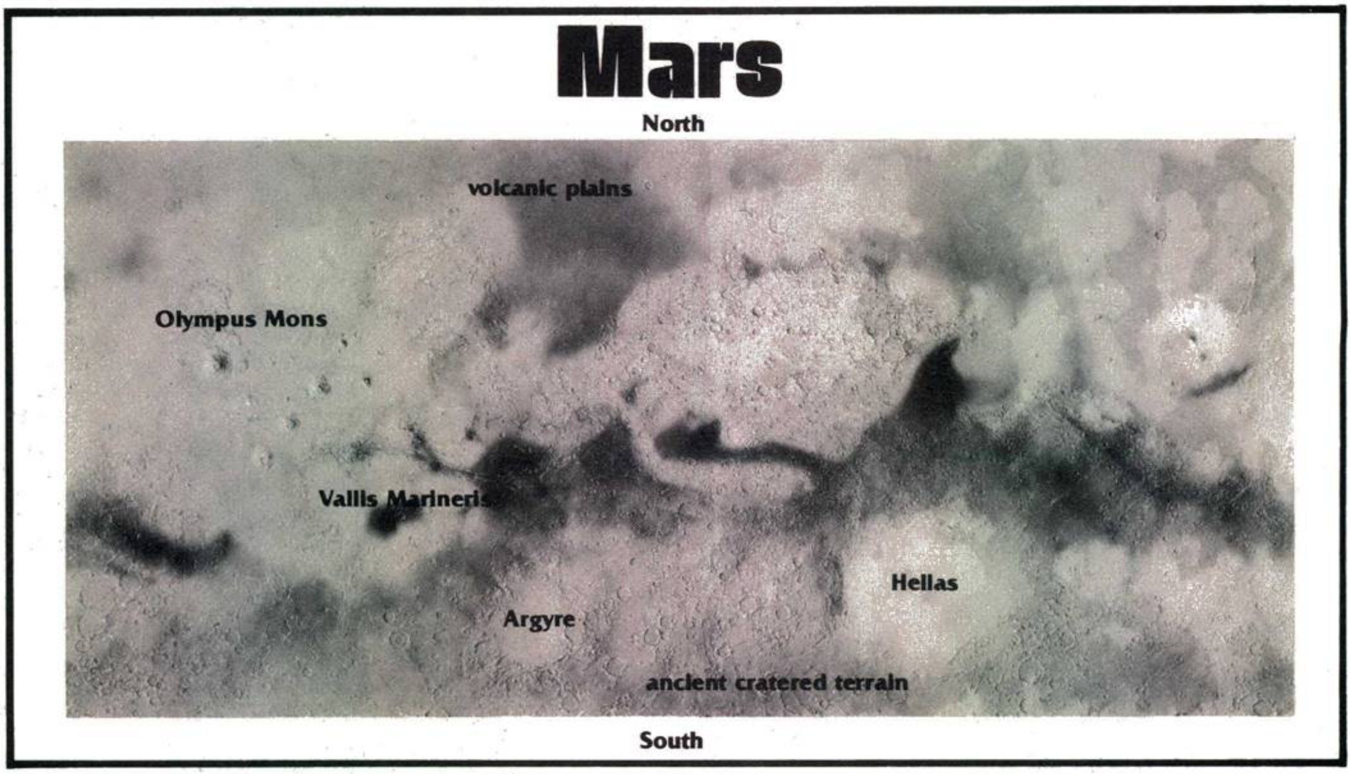
Mariner 4 shot past Mars in 1965. It returned 22 close-up pictures — showing craters! But the areas photographed were so small that astronomers could not relate the new images to the telescopic features. Mariner measured the atmosphere, finding it only 1% as dense as Earth's, and made of carbon dioxide. Mars suddenly seemed hostile — even Moon-like.

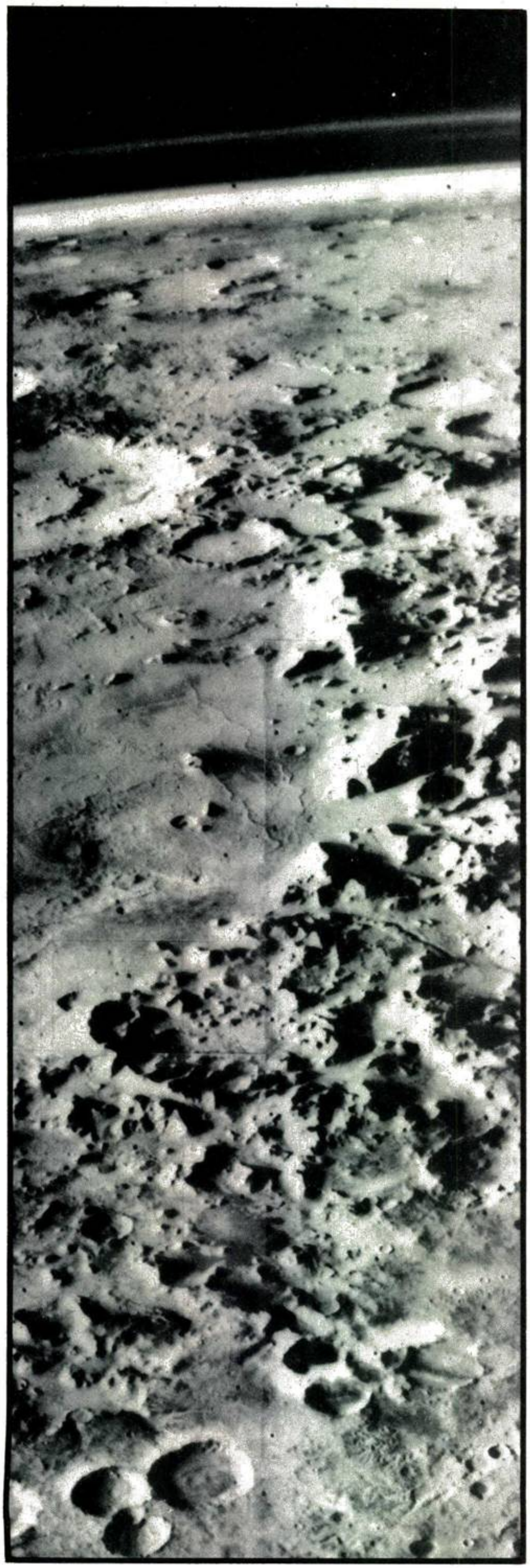
In 1969, two spacecraft, Mariner 6 and Mariner 7, flew past Mars and radioed back 200 pictures. This time, dozens of medium resolution pictures were taken during the approach — pictures showing the "classical" brightness features of Mars, as well as close-ups of a tiny fraction of the planet's surface.

Planetologists quickly recognized two classes of craters — small new-looking craters and flat-bottomed "old" craters. The smooth, craterless floor of the Hellas Basin suggested the lunar maria. But here comparisons with the Moon ended.

Mars — unlike the Moon — is eroded. Wind and water have altered the planet. Nothing like the etched and pitted polar landscapes of Mars or the chaotic terrains in its equatorial regions is seen on the Moon. At a resolution of 500 meters, Mariner 6 and 7 revealed not another Moon, not another Earth, but a uniquely martian landscape.

Two years later, another spacecraft from Earth — Mariner 9 — arrived at Mars. (Mariner 8, also bound for Mars, had crashed into the Atlantic Ocean shortly





Mars 5 years after

after lift-off, due to a rocket malfunction.) This time, the spacecraft went into orbit about Mars and stayed functioning for two years, returning over 9,000 pictures.

Its mission was to map the planet. But Mariner 9 had arrived at a bad time. Dust storms blanketed the planet. Virtually nothing of the surface showed anywhere. Slowly the storms abated and the dust began to settle. On the side of Mars opposite that seen by Mariners 6 and 7, early Mariner 9 pictures showed three dark spots in a line just north of the equator and another larger one nearby. As the atmosphere cleared, stunned scientists saw that the spots were actually three huge volcanos and one enormous volcano on the spot telescopic observers called Nix Olympica, "the snows of Olympus." We now call that giant volcano Olympus Mons.

So Mars *was* active — or at least it had been active in its past. As the clearing continued, the Mariner 9 cameras revealed a huge system of canyons and valleys stretching along the equator for one-quarter of the circumference of the planet: they were wide and deep enough to swallow Earth's Grand Canyon— 10 times over.

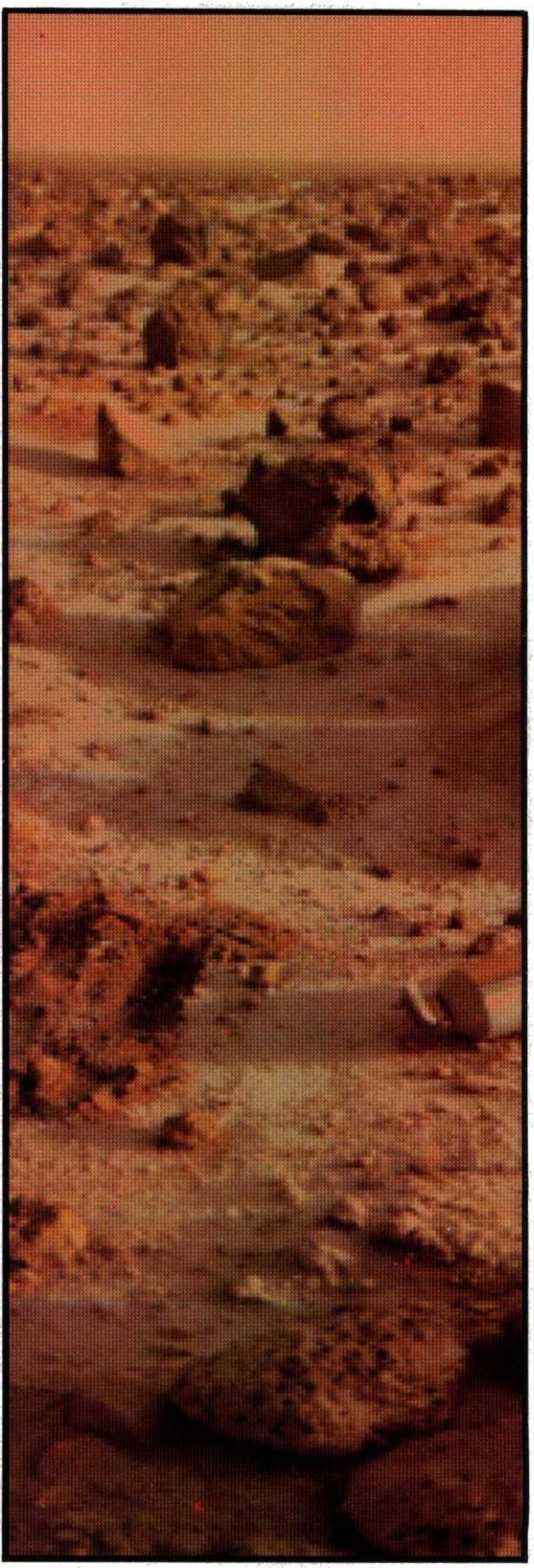
But the crowning discoveries were more subtle. All over Mars, but especially near the equator, Mariner 9 found channels that looked suspiciously like flow channels made by water. Mars is dry now — at least superficially dry — but perhaps great floods of water once poured across its surface. In the polar caps, the pictures returned to Earth showed dust and ice in layered deposits — as if the climate of Mars swung through a many-thousand-year cycle of warm and cold. The prospects for alien life now seemed slightly less dismal.

Five years later, two American spacecraft — Viking 1 and 2 — once again approached Mars. The purpose of the Viking mission was dual: to study the geology and the biology of Mars. Viking was to explore the entire planet — from orbit — in great detail, with cameras and remote sensing instruments aboard the two orbiters. On the surface, two landers were to determine the chemistry and composition of the crust, study the composition of the atmosphere, monitor the weather, and detect Mars-quakes. The landers also searched for life.

All four machines functioned almost perfectly: Viking 1 arrived at Mars on June 19, 1976, its lander touching down in Chryse Planitia on July 20; Viking 2 arrived on August 7, and landed in Utopia Planitia on September 3. Although designed for a primary mission of 90 days, the spacecraft lasted for years. Viking Orbiter 2 quit because it ran out of attitude control gas after three years; Orbiter 1 ran out of gas

The rim of Argyre Planitia, an ancient impact basin in the southern hemisphere of Mars.

In martian winter, a thin yellow-white frost forms on the rocks at the Viking Lander 2 site.



after four years, leaving Lander 2 still functioning but incommunicado. Between them, the orbiters returned over 37,000 high-quality images of the red planet. Lander 1 still transmits its data directly to Earth and will continue to transmit until 1990.

Mars: the Post-Viking View

Viking marks the end of the first stage in the exploration of Mars — an intimate acquaintance with a planet formerly known only from a distance. We now know Mars as a planet of great diversity, a planet that continued volcanic activity for billions of years, a planet whose surface has been sculpted by wind and water.

The most significant feature of the martian surface is its division into two strikingly different hemispheres along a line tilted about 35° to the equator. On the southern half, Mars is covered with battered old craters — the degraded scars of ancient impacts. Apparently this is the primordial Moon-like surface of Mars. Crisscrossing the cratered terrain are enigmatic dry channels — some looking fresh, others degraded almost to invisibility — plus a variety of landforms suggesting water and a dense atmosphere.

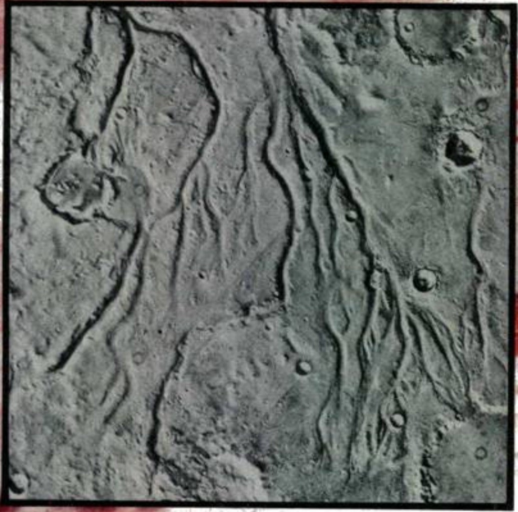
The northern half is covered with smooth, sparsely-cratered volcanic plains. Near the equator, some plains still resemble lava flows, and display many volcanic features. Both Lander sites lay in this hemisphere, and from the ground, both turned out to be rocky, barren deserts. Lander 1 radioed back pictures of spongy rocks, gently rolling hills, dust dunes, and outcrops of bedrock under a salmon-pink sky. Lander 2, targeted considerably farther north on more fractured plains, apparently set down on material thrown out in the formation of a large, fairly young crater, Mie. Its site was flatter and rockier, and no dust dunes or exposed bedrock were visible.

Lying astride the boundary between the two terrains is the great Tharsis bulge. Tharsis is the most

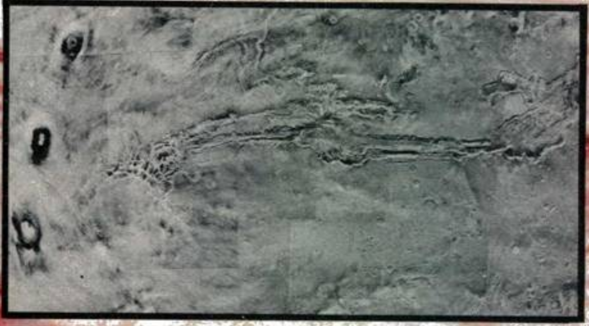
Mars Data

Mean Distance from Sun	**1.524 AU**
Eccentricity of Orbit	**0.093**
Period of Revolution	**687 Earth days** **669 martian days**
Martian Day (Sol)	**24 hours 37 min. 22 sec.**
Inclination of Axis	**25°**
Equatorial Diameter	**6787 km**
Polar Diameter	**6752 km**
Mass	**0.108 Earth masses**
Density	**3.9 gm/cm³**
Atmosphere	**carbon dioxide - 96%** **nitrogen - 2%** **argon - 1%** **other gases - 1%**
Atmospheric Pressure	**0.6% Earth** **7 millibars**
Average SurfaceTemperature	**-23°C**
Surface Gravity	**38% Earth**
Satellites	**2**

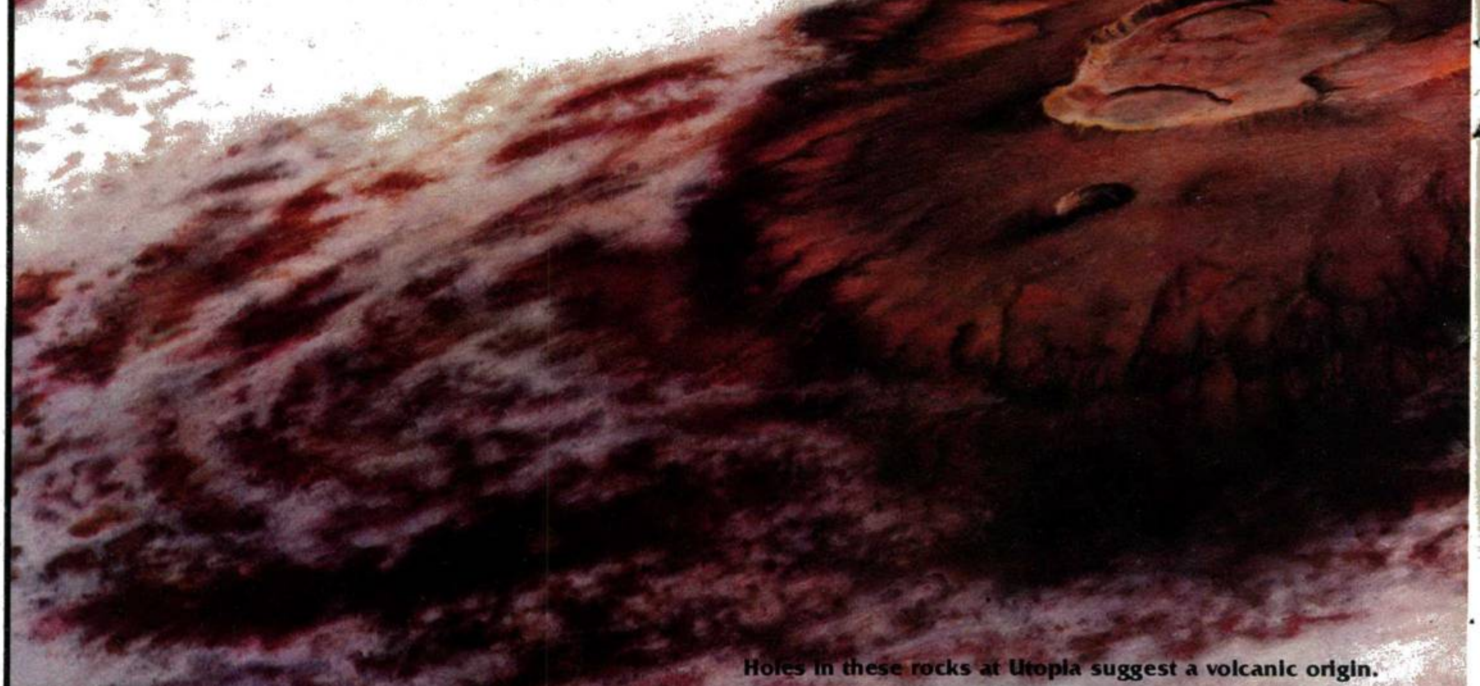
Mars 5 years after



The cratered plains of Mars often show channels resembling those made by water.

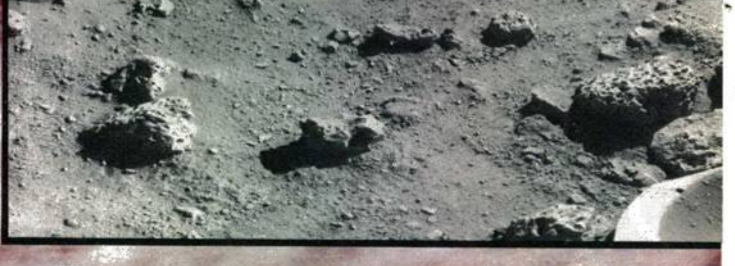


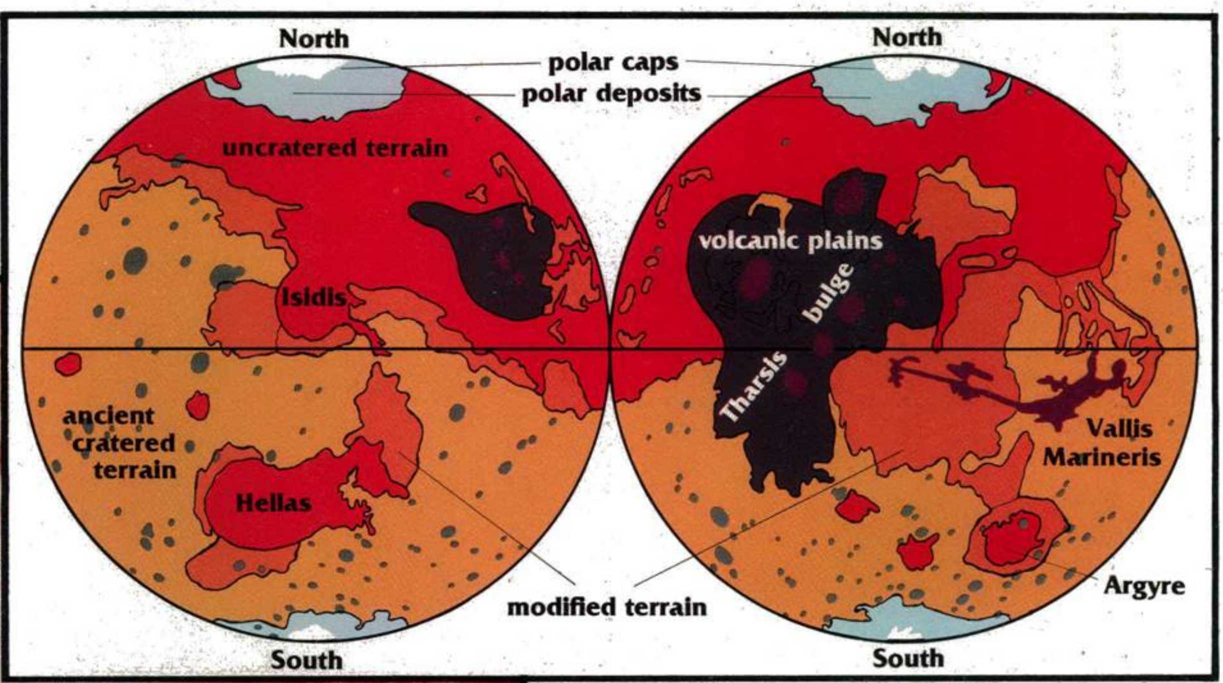
Kilometers deep, Vallis Marineris stretches thousands of kilometers along the martian equator.



Rising above the clouds, the summit of mighty Olympus Mons testifies to millions — even billions — of years of volcanic activity in a long-past era.

Holes in these rocks at Utopia suggest a volcanic origin.





significant feature on Mars — a huge lump on the side of the planet. It covers fully a quarter of the surface.

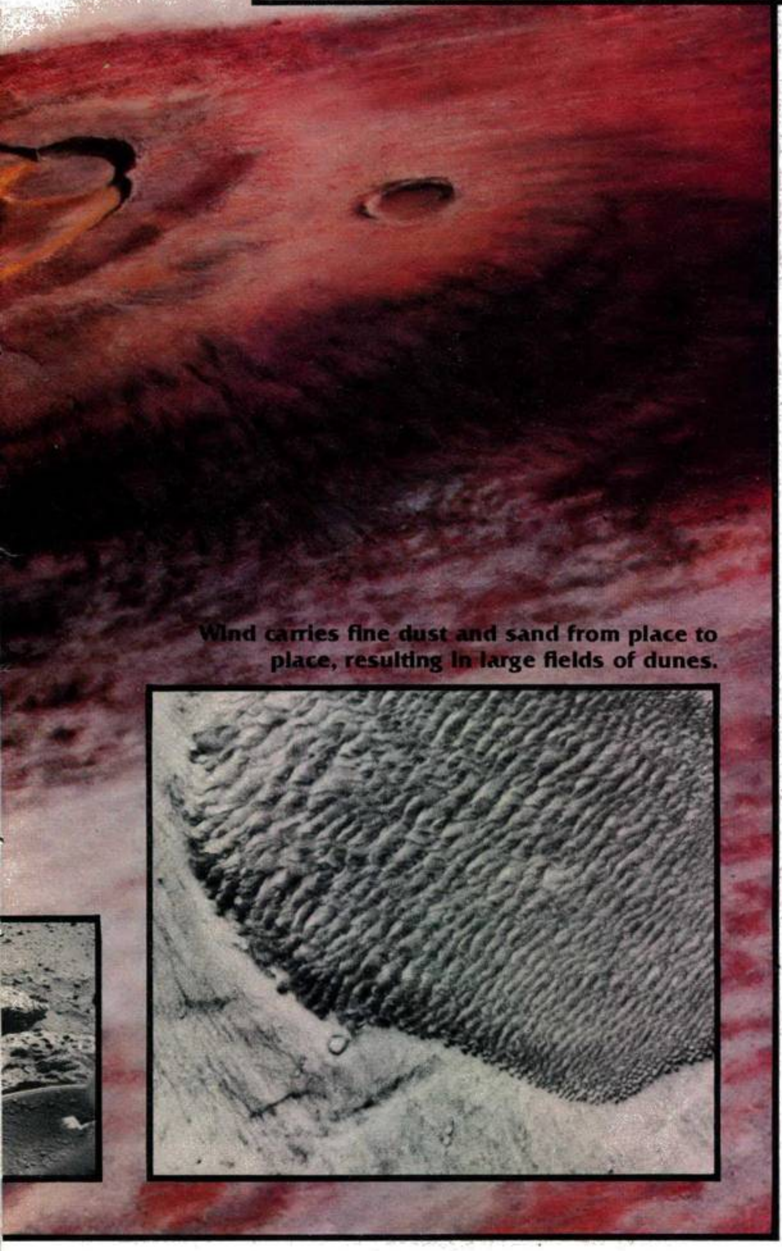
From the Tharsis bulge rise the giant martian volcanos, the highest of which, Olympus Mons, stands 27 km above the mean surface of Mars. Its base extends 600 km across, and beyond that, the volcano is surrounded by grooved terrain, or "elephant hide." Olympus resembles shield volcanos on Earth, but it is larger by far than the Hawaiian islands, the largest terrestrial volcanos.

Along the peak of the Tharsis bulge is the line of three great mountains — Arsia, Pavonis, and Ascraeus — great shield volcanos in their own right, but dwarfed by Olympus. At the summit of each is a caldera, or volcanic pit, up to hundreds of kilometers across.

The second largest volcano is Alba Patera, a volcanic "mountain" of a type so far found nowhere but Mars. Alba is 1,800 km across but only about 4 km high — an enormous but inconspicuous outpouring of lava. Its slopes are so gentle that if you were standing on Alba Patera, you might not even notice it. The lava that poured from the central vent must have been extremely fluid to spread so far.

From counts of craters, the volcanic plains must be much younger, much more recently formed, than the ancient terrains in the southern hemisphere. Olympus itself is younger than Tharsis — a mere 2.5 billion years old — and its three smaller companions considerably younger. Furthermore, the span during which the youngest volcanos erupted must have been very long, perhaps billions of years. Their activity seems to have ended perhaps 500 million years ago.

Surrounding Tharsis, a system of radial faults and cracks in the crust attests to the profound geological forces required to raise such a swelling. The most conspicuous of these faults is Vallis Marineris, a network of canyons and valleys 4500 km long — nearly long enough to span the United States east to west — extending radially away from the center of Tharsis. As planetologists envision it, when Tharsis



Wind carries fine dust and sand from place to place, resulting in large fields of dunes.

Mars 5 years after

began to bulge early in the history of the planet, about 4 billion years ago, the surface spread. Sections dropped down to become the floors of canyons. In the billions of years following, landslides, erosion, and deposition have enlarged it. Today the widest part of the largest canyon in Vallis Marineris is 700 km wide and some 7 km deep.

Like the Moon, Mercury, and Callisto, Mars displays several conspicuous multi-ringed basins dating back to the time when debris left over from the formation of the planets was swept up — some 4 billion years ago. The largest basin, Hellas, 1600 kilometers in diameter, lies almost directly opposite Olympus Mons on the other side of the planet. On Earth, such basins have been destroyed by subsequent geological activity; on our geologically dead Moon, they are preserved almost intact. On Mars, we find Hellas, though worn, is still the lowest region on the planet, 6 km deep. Argyre and Isidus are the next largest of the martian basins.

Both underlying and cutting through craters in the old terrains are the run-off channels. Although

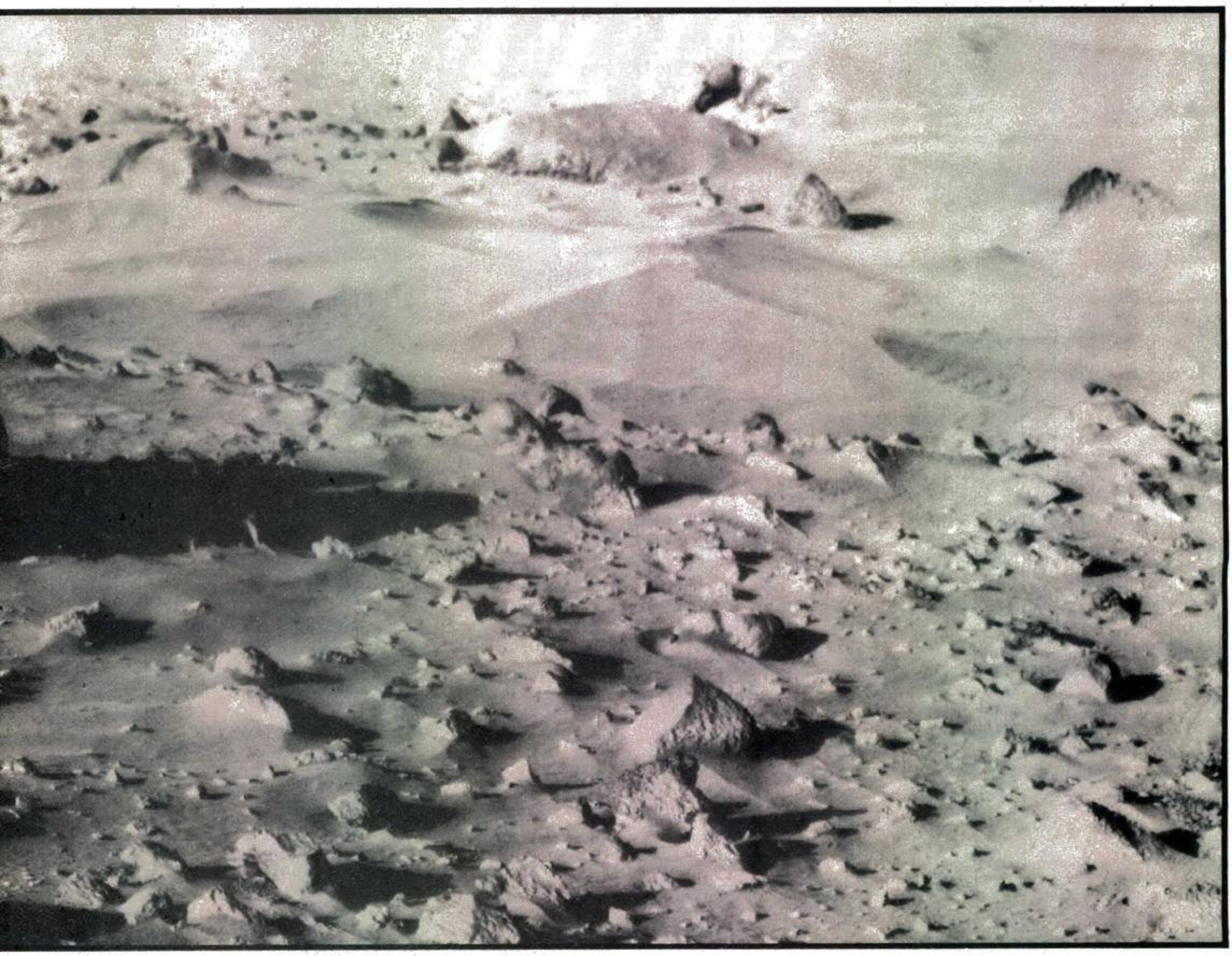
Mariner 9 discovered them, it took Viking's sharp imagery to convince many conservative planetologists that they were most likely caused by running water. Channels exist in all states of preservation — from crisp "new" ones to those that are nearly obliterated. Most lie in the ancient cratered hemisphere of Mars. Because craters have impacted and demolished channels, and other channels have eroded and breached craters, the channels and craters must be contemporaries — and must have formed early in the history of Mars. The "immature" drainage patterns of the channels suggest that if there was running water, it was released very rapidly, in giant floods.

Today liquid water cannot remain liquid long at the temperatures and pressures found at the surface of Mars. Water, if it exists, must either be ice or gas. If Mars formed from the solar nebula — as we think it did — it should have begun with the equivalent of many tens of meters of water over all its surface. The flow channels point very strongly toward a time in the distant past when water was a powerful erosive agent, carving channels and cutting through the crater walls of an ancient Mars.

Where, then, has the water gone? If Mars was once warmer and wetter than it is now, there must be a major reserve somewhere on the planet. Some lies frozen in the polar caps, seasonally buried in carbon dioxide snows, and more could be incorporated as permafrost in the -60° C martian soil. Where ice may have thawed and re-frozen as the climate cycle of Mars changed, we see collapsed and eroded ground — hilly, fractured, and fretted — all suggesting erosive processes that signal subsurface ice.

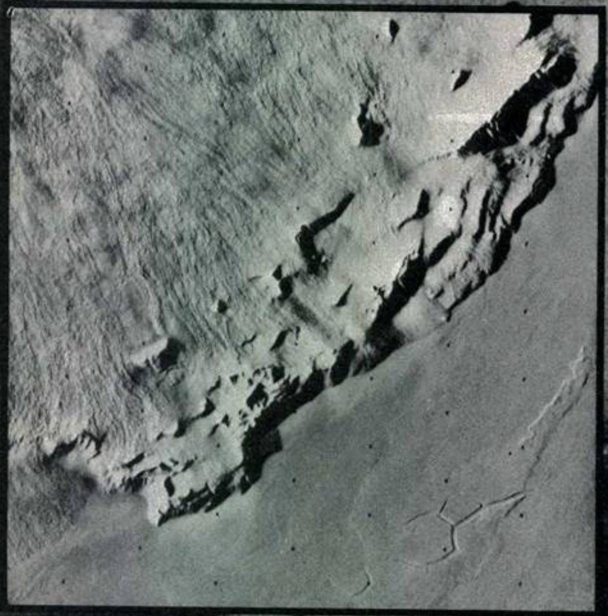
Covering the rotational poles of Mars are permanent water-ice polar caps and transitory caps of frozen carbon dioxide that grow each martian fall and winter and shrink in the spring and summer. Because of Mars' eccentric orbit, the southern polar cap now undergoes a greater variation in solar input than the northern pole. The southern cap is therefore larger in winter and smaller in summer than the northern one. As the orbit and tilt of the pole slowly vary, martian conditions may have changed cyclically in the past.

Left: A broken and faulted region, Noctis Labyrinthis, runs east from the Tharsis volcanos.

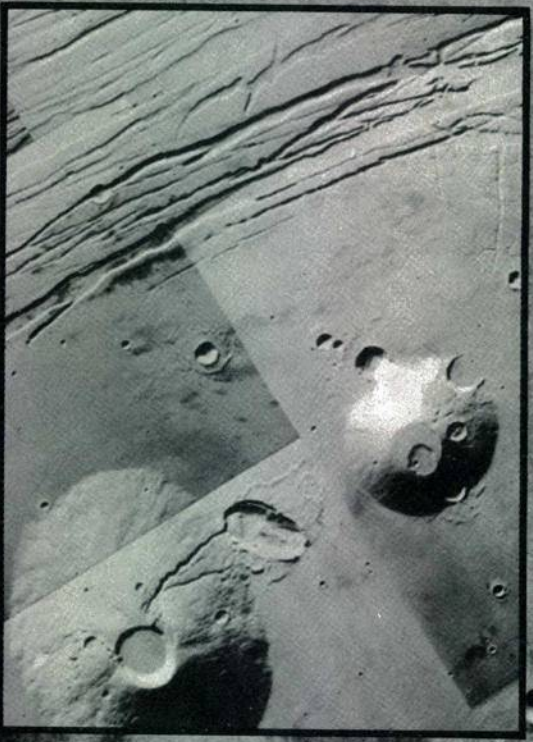


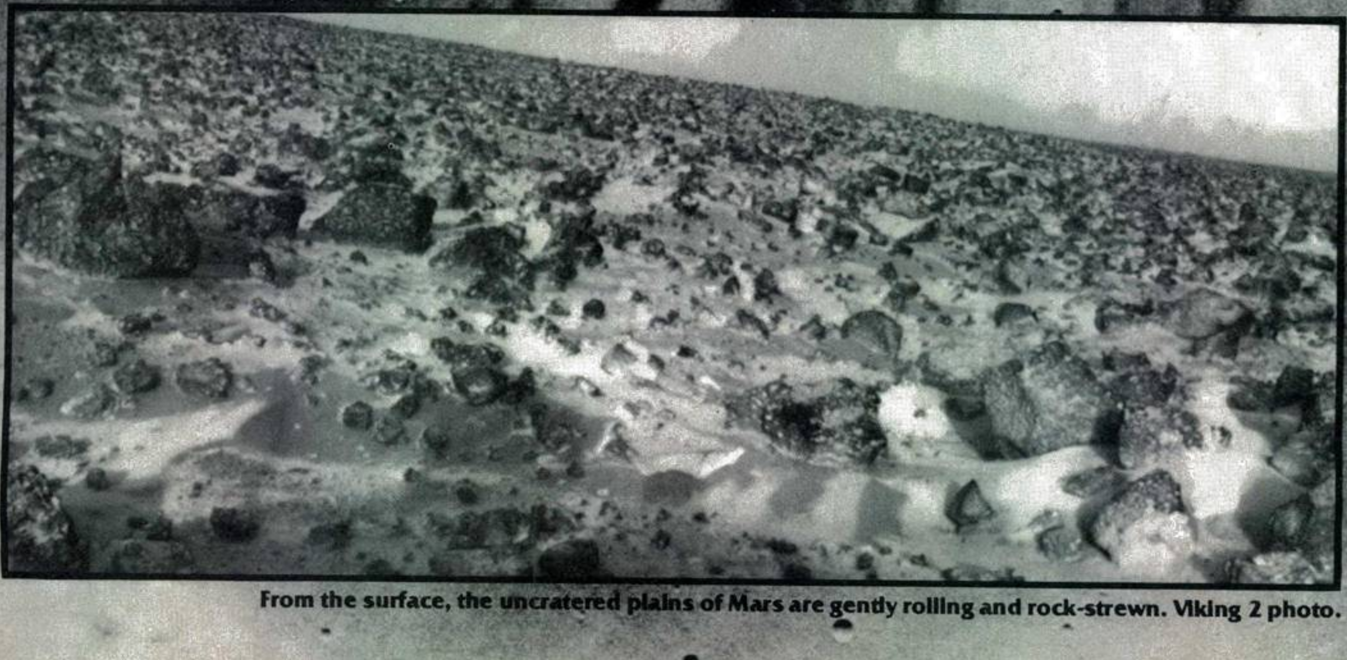
Big Joe, a rock about 2 meters across, is surrounded by dust drifts now very slowly eroding away.

Streams of long-cold lava cascade over the 3,000-meter cliff at the base of Olympus Mons.



Faults and volcanos are related. These cracks were made when the Tharsis region uplifted.





From the surface, the uncratered plains of Mars are gently rolling and rock-strewn. Viking 2 photo.

An enormous flow of water may have cut the channel through the wall of this 28-kilometer crater in the Mangala Sinus, a region of ancient cratered plains.

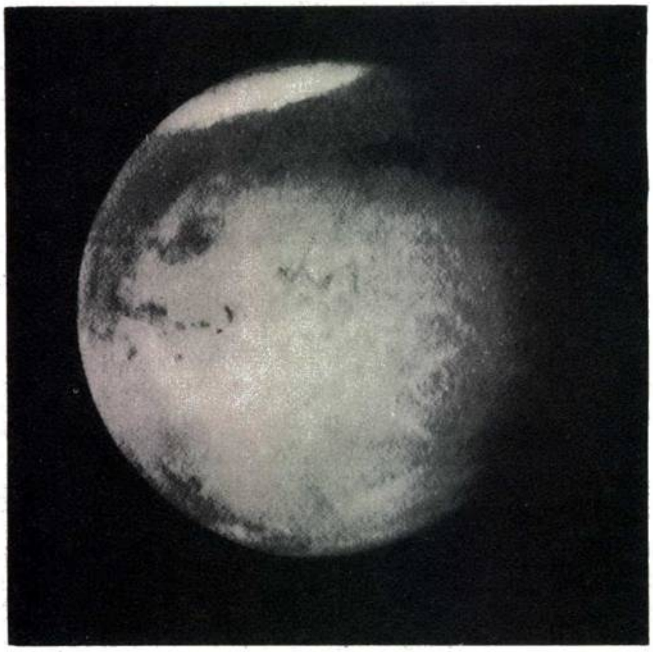
Mars 5 years after

How much water is locked up in the polar caps? There has been no way to determine how thick the polar caps are, though estimates range from 1 meter to 1 kilometer, and therefore the amount of water and carbon dioxide stored in them remains unknown.

The role of wind on Mars is — or perhaps has been in the past — important. Thin layers of dust cause the telescopic dark markings — dust deposited and blown away by wind. Dust storms frequently mask the planet in opaque orange clouds. Over the ages, wind has cut rock: wind-sculpted yardangs — rock formations familiar in terrestrial deserts — testify to that. The polar caps contain large amounts of dust mixed with the ices, and surrounding the caps is a broad belt of dust dunes. Yet the pace of change on Mars now seems to be slow: the Viking landers saw minimal changes in the landscape: the removal of a few millimeters of dust could take a thousand years.

And what of the search for life? The lander experiments were not conclusive, so for years there will surely be scientific arguments about the results. The martian soil sampled contained no detectable organic material. Furthermore, the soil appears to be chemically oxidizing. Considering the dryness, the solar ultraviolet light, the harsh soil, and the lack of organic compounds, it would be difficult for terrestrial microbes to live on Mars. If there *is* martian life, it must be sparse, tough, and extremely alien.

In 1969, Mariner 6 recorded the "volcano side" of Mars. At such low resolution, the most striking features of Mars went unrecognized.



Gravity Lenses:
A Focus on the Cosmic Twins

by Emilio Falco and
Nathaniel Cohen

The always-close relationship between astronomy and physics has become even closer in recent decades. Slip-streaming on each others' discoveries, both sciences have pushed back the boundaries of the unknown with striking vigor. One of the most exciting aspects of this advance has been astronomy's confirmation that certain strange objects proposed by theoretical physics actually do exist.

Among these strange-but-true predictions (which have included neutron stars and black holes), are naturally-occurring *gravitational lenses* in space. First proposed just after the turn of the century, gravity lenses recently became a reality when astronomers discovered one of them in the constellation Ursa Major.

Actually, gravity lenses aren't so rare — but seeing one is. We even live in a gravitational lens — our own Milky Way Galaxy. The existence of a large mass (such as a galaxy) puts a "dent" in the space-time around it. This causes the paths of light rays that pass near it to curve. If conditions are right, every large mass acts like the glass in an optical lens — and brings light to a focus.

If anyone deserves to be called the father of the gravitational lens, Albert Einstein does. In the early years of this century, he stated that gravity ought to bend light and predicted that a ray of starlight which just grazed the edge of the Sun would be deflected by an angle of 1.75 seconds of arc, thus shifting the star's apparent position.

In 1919, this prediction was triumphantly confirmed by observations made during a solar eclipse. When they measured photographs of stars lying near the eclipsed Sun in the sky, astronomers found the stellar positions displaced by a tiny but perceptible amount. Moreover, the amount of displacement was very close to that called for by Einstein.

The result was history: Albert Einstein, a 40-year-old professor of physics unknown to the public, became "Mr. Relativity", a fixture of popular culture.

But away from the ballyhoo, the question lingered among scientists: If gravity bends light rays, could it also produce images — as an optical lens does? In 1936, Einstein himself turned to the theory behind the phenomenon and showed that a star indeed could focus the light of another star lying at a greater distance. However, when he worked out the chances of seeing the effect, Einstein thought they would be negligible. Why? Because the lens effect becomes appreciable only when the observer, the "lens," and the source are all nearly aligned — a coincidence so rare it has an infinitesimal probability.

Though this result was discouraging, a year later astronomer Fritz Zwicky suggested another perspective on the problem. Since distant galaxies have very large masses and are quite abundant, he reasoned, the probability of observing a lens effect with galaxies was much better than with stars. Unfortunately, his paper went unnoticed. For years afterward, no astronomer gave much thought to gravitational lenses because they still believed, as did Einstein, that the likelihood of an alignment was too small.

Not until the 1960s did physicists explore the imaging problem in greater detail. When they did, they found a multitude of intriguing theoretical possibilities. Depending on the arrangement of the elements in a simple gravitational lens system, an observer might see a thin ring, two narrow crescents, or two small elliptical images.

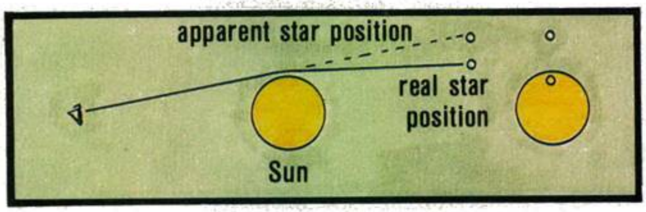
While it seems abstruse, the theory has a surprising amount in common with ordinary optics — at least as far as predictions go. The difference lies in how the lens bends light. General relativity states that the distortion of space in the vicinity of a massive object will deflect a light ray with an angle of deflection directly proportional to the mass of the lens-object, and inversely proportional to the distance the light passes from the lens-object.

Armed with these assumptions, Sidney Liebes and Sjur Refsdal in 1964 worked out the imaging properties of simple gravitational lenses. Their computations predicted a fairly good chance for observing the effect with globular star clusters and galaxies as lenses. And, as their light sources, they used stars and supernovae.

In the following year, Jeno and Madeleine Barnothy proposed that the strange, bright objects called quasars (then newly-discovered) might be the gravitationally magnified nuclei of distant Seyfert galaxies — spiral galaxies with small, bright cores. But soon many more quasars were found, indicating they were clearly something else. Once again the subject lapsed, although more work was done sporadically during the following fifteen years. Gravitational lenses, it seems, remained only an exotic possibility.

The breakthrough came two years ago, when astronomers Dennis Walsh, Robert Carswell and Ray Weymann used the 2.1-meter telescope at Kitt Peak

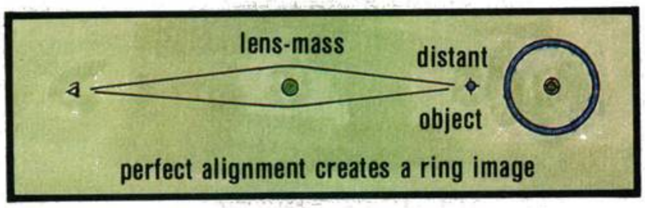
National Observatory to find an odd pair of quasars near the Big Dipper. The quasars lay on an almost north/south axis and observations showed that they were separated by only 6 seconds of arc (about the size of a light bulb seen from a distance of two miles). Astronomers labeled the northernmost quasar A, the other B, and following standard astronomical practice, named the pair "0957+561 A, B" after their position in the sky (at 9 hours 57 minutes right ascension and +56.1° declination).



Curiously, the quasars' spectral lines were shifted toward the red end of the spectrum by exactly the same amount. (The redshift of a quasar's spectrum is an indirect measure of its distance from us.) The redshift put 0957+561 at a distance of about 3 billion light-years. Besides having the same redshift, the spectral characteristics of A and B were also virtually identical. The only difference was that A was brighter by a constant ratio at every frequency.

The chance of finding two identical quasars lying so close together is very small. Indeed, statistical calculations showed that two quasars with such a tiny angular separation *and* identical redshifts *and* identical spectra just could not be chance. They had to be "twins" of some sort — but were they real twins or only apparent twins?

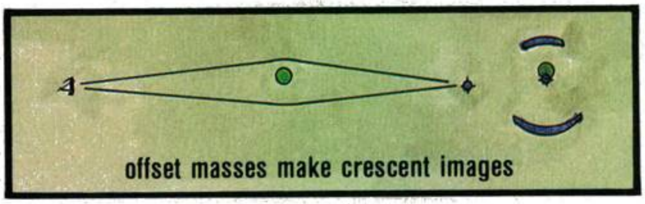
Astronomers first guessed that they were physically coupled, but they soon ran into problems. There is no known way to produce and maintain such a close pair of sources with such similar spectra. This meant the grouping was more likely to be an apparent pair — a double image of one quasar. It was then that astronomers realized they were seeing the long-predicted gravitational lens in action.



When they measured the brightness of the twins at different wavelengths, the astronomers found further support for the "lens" hypothesis. At radio, infrared, visible light, and ultraviolet wavelengths, the ratio of brightnesses for the twin components was about four to three (A to B), and independent of frequency. With a gravitational lens (in contrast to a glass lens), wavelength has no effect on the image, so this is what they expected to find. Yet if A and B were separate objects, they would be a rare find. It would be extremely unlikely to find two distinct quasars that would conform in brightness over such a broad range of wavelengths.

However, there were still some problems with the gravitational lens interpretation. Detailed radio maps showed that A had jets or lobes extending about 5 seconds of arc to the northeast and west. B also had a jet, but it extended only about 2 seconds of arc to the north. Neither resembled the other. Clearly, if the twin quasars were an image formed by a gravitational lens, the situation had to be rather complex. Moreover — where was the lens itself?

Further insight into the twins' nature came from sophisticated optical and radio measurements. Peter Young and his Caltech colleagues attached a new type of very sensitive instrument called a CCD camera to the 200-inch telescope at Mt. Palomar. (See "An Imaging Revolution," ASTRONOMY, November 1980.) They found that B and its jet actually consisted of two images just 1 arc-second apart. They also found a large cluster of galaxies surrounding the twin images in their photographs.



Young and his coworkers concluded that the double image called B was a composite image of a foreground galaxy displaying slightly less than a third of A's redshift and the actual second image of the quasar. Pieces of the puzzle seemed to be falling into place — would this new galaxy be the essential but yet-unseen lens?

Maybe, but not until many more questions were asked. The new galaxy and images A and B were not aligned in the "proper" way to create a gravitational lens. Clearly, this was not a simple lens. The observations, however, were providing four new elements in support of the lens.

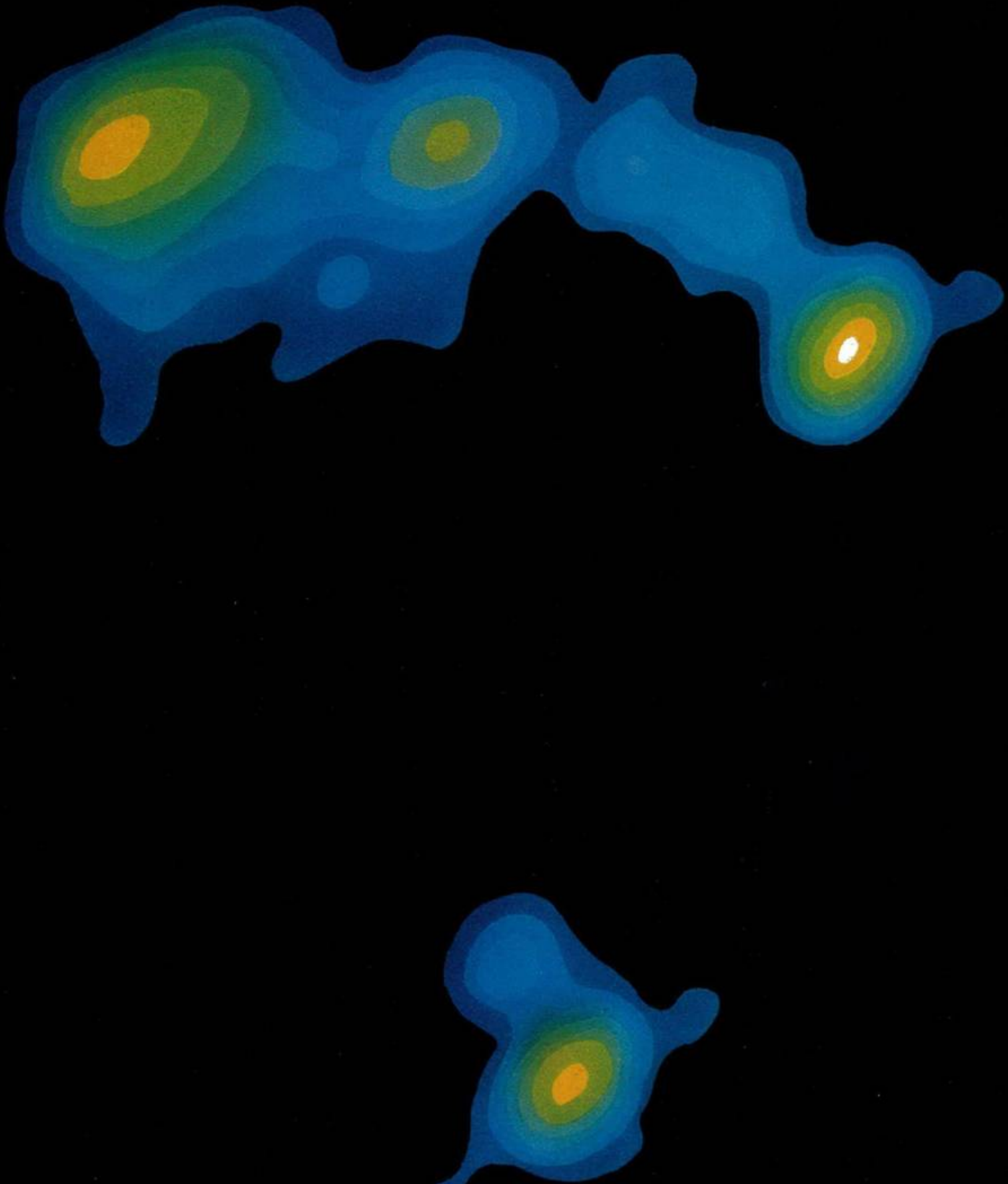
First, the galaxies in the cluster are all part of the lens system. Although each galaxy can work only an exceedingly small deflection on the light rays, there are many galaxies in the cluster. Together their mass might be large enough to produce an appreciable displacement of images A and B. This removed the first stumbling block — the misalignment of A, B, and the main galaxy.

Second, the light that forms the B image clearly traverses a large portion of the main galaxy, while A lies much farther away. This disparity could account for the slight differences between the spectra of A and B. The image of B that we see actually contains some light emitted by the main galaxy itself.

Third, the main galaxy appears to be elongated rather than spherical: astronomers have identified it as a type cD galaxy. These giant elliptical galaxies have very large masses (more than a trillion suns) and very little absorbing gas between the stars — ideal galaxies to provide relatively large deflections of light rays.

Fourth and last, the cluster of galaxies itself is not a sphere. Having an approximate elliptical shape, the cluster's effects on the image would skew the

A Radio Image of
0957+561 A,B

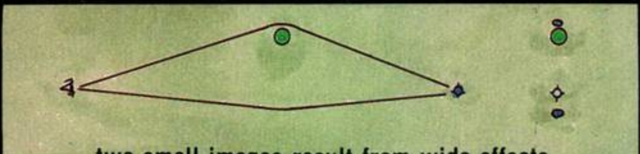


artwork by Mark Paternostro

deflection further.

The result is that A is the image of the actual quasar with its position deflected only slightly, and B is the secondary image of A formed by the galaxy. We can't see the A jets' second image because they lie too far (from our vantage point) from the imaging galaxy.

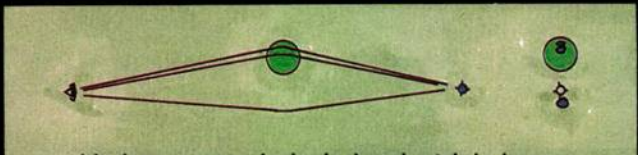
But type cD elliptical galaxies, according to theory, ought to create an odd number of images: one, three, or five, depending on the position of the light source. Since we see only the two, there must be a third image hidden somewhere. Calculations show it ought to be close to B — but so far it hasn't been found. The lack of a third image worries astronomers a little; they are hoping that it exists, but is too weak to be detected with present-day instruments and techniques.



two small images result from wide offsets

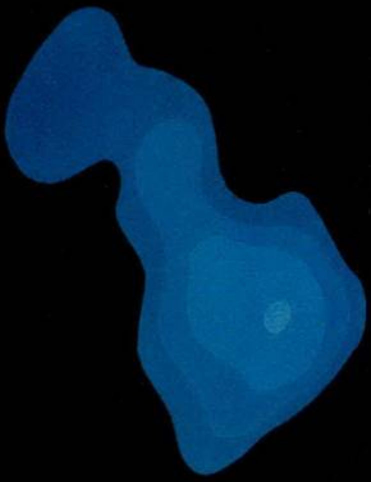
Looking elsewhere, a triple quasar appears to have been discovered by Ray Weymann and his collaborators last summer. If the triple image turns out to be gravitationally-produced, astronomers may have to revise some of their ideas about the universe. Why? Finding another gravity lens would imply that such lens effects are not very rare after all and, in a slightly roundabout way, this would mean gravity lenses could provide a much-needed check on the size, age, and mass of the universe.

The ultimate fate of the cosmos depends on the total amount of mass it contains. If the mass exceeds a certain value, the expanding universe will slow down, stop, and finally collapse back on itself. If large masses are very abundant, but invisible except when they image the light emitted by background objects, our current value for the total mass of the universe may be far too low. The mass we can account for now is about 10 to 100 times short of that needed to "close the universe" — but it's entirely possible that significant amounts of mass have yet to be discovered.

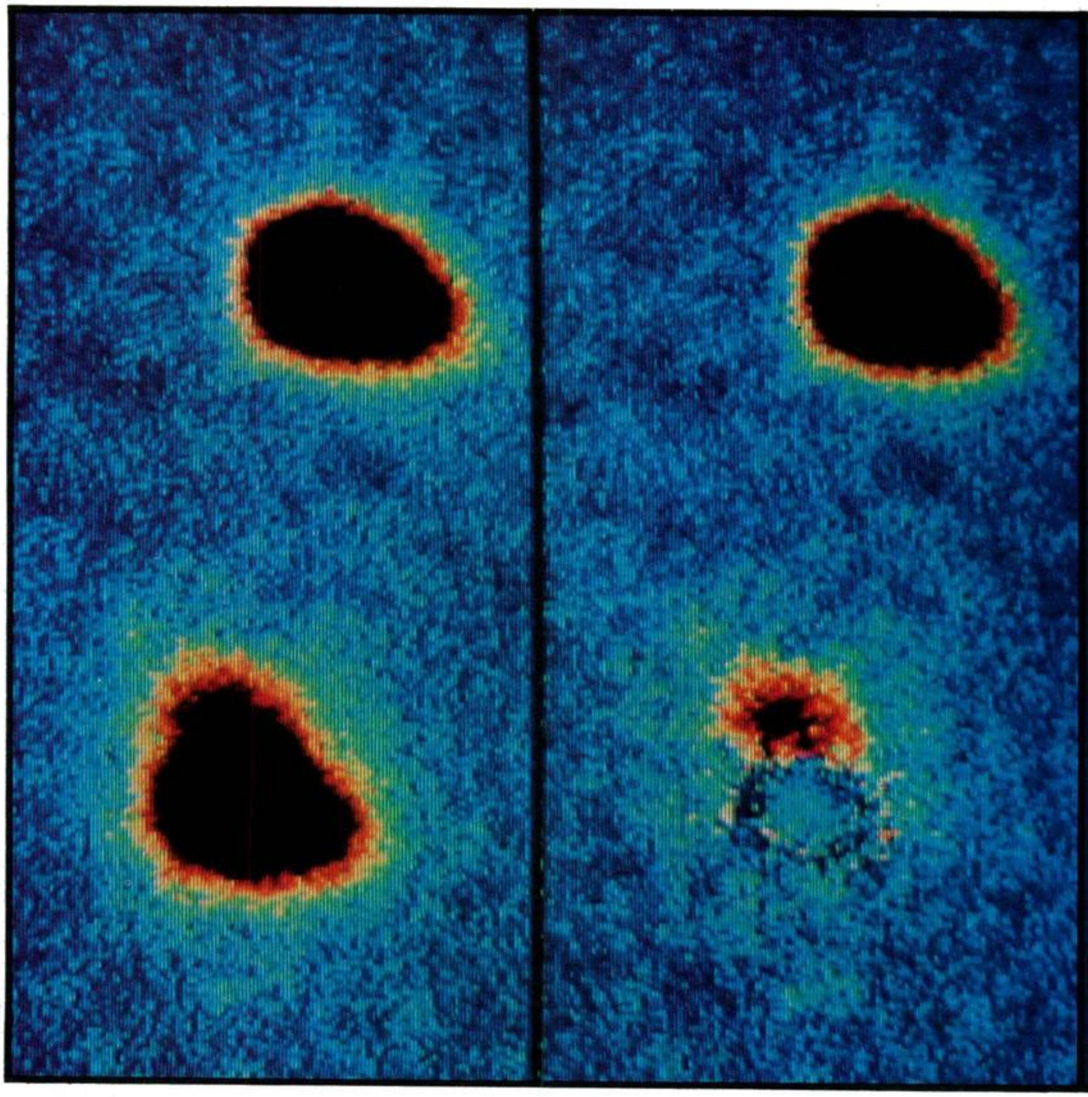


big lens-masses (galaxies) make triple images

The large-scale structure of the universe depends a great deal on just two numbers. First, the raw size of the cosmos depends on the value assigned to Hubble's constant, because the constant tells how far away a galaxy is by how fast it is receding. Second, the deceleration parameter tells the rate at which the expansion of the universe is slowing down. Unfortunately, we have only estimates of these critically important numbers. Any new method that



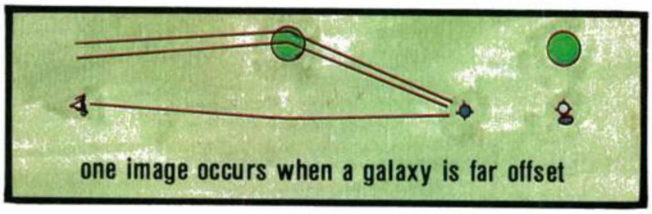
At the radio wavelength of 6 centimeters, 0957+561 A,B shows the classic double-jet quasar structure (bright upper image with side-lobes) and a bright image of the quasar called B (lower image).



By using computer processing to subtract the image of the quasar from the B image, astronomer Alan Stockton revealed the lens-galaxy itself. Compare the unsubtracted, "raw" image (far left) with the processed version (near left) which shows the galaxy. Photograph from the Institute for Astronomy and Planetary Geosciences Data Processing Facility, University of Hawaii.

would pin them down more closely would be a great step forward for astronomy. (See this month's Stellar Frontiers.)

One promising approach lies in the way astronomers have seen quasars dramatically change brightness — sometimes in a period of days. In the case of the twin quasar, for instance, the brightness of B has been changing over the last few months. But light emitted at the source quasar can arrive at Earth along two different paths, A and B. Therefore, the light that forms A takes a different time to reach us than the light that forms B. If the source brightness changes, the A image should change first. The same variation ought to be observed some time later in B.



one image occurs when a galaxy is far offset

Measuring the time delay may provide us with a check on the distance to the source, and with an indirect measurement of Hubble's constant. If the predicted third image is found, the time delays between the three images would yield enough data to calculate the deceleration parameter. And naturally, other gravity lenses would help astronomers cross-check the results.

In years to come, gravitational lenses could become an extremely useful tool in astrophysics. They could provide a test of Einstein's general theory of relativity over cosmic distances. The lens effect would also support the idea that quasars are in fact very distant sources, still a matter of some dispute among cosmologists. Gravitational lenses may also give us a probe for the distribution of mass in distant galaxies — almost completely unknown except in our own Galaxy — and in clusters of galaxies.

Some even suggest we use the Sun as a lens for amplifying signals from possible extraterrestrial civilizations. Of course, the list of speculations could go on forever, but as we've seen so often before, reality could very well surpass all our expectations.

Emilio Falco is a Research Assistant working for his Ph.D. in astrophysics at M.I.T. He is actively pursuing research on gravitational lenses and the twin quasars. Nathaniel Cohen is a Visiting Scholar at M.I.T., on leave from Cornell University where he is studying for his Ph.D. in astronomy. He is also involved in active research on the twin quasars.

The 1981 Rolex Awards For Outstanding Enterprise

The Rolex Awards for Enterprise is an international program to provide financial help and special encouragement for individuals whose projects have broken new ground in their chosen fields. These projects capture that spirit of enterprise which has been such a characteristic of the development of the Rolex watch. Here are the five award winners of 1981 with a resume of their projects.

A Blueprint for Disarmament — Seymour Melman

If global disarmament ever is to be achieved, one vital step in the process will be to convert industrial economics from military to civilian work. Seymour Melman, an American Professor of Industrial Engineering, has been exploring myriad technical, economic and organizational changes required to make such conversions work.

As industrial economics vary widely, Professor Melman is formulating three representative models for conversion: the U.S.A. and Western Europe, the Socialist countries, and the less-developed countries.

His 1981 Rolex Award for Enterprise will enable Professor Melman to develop his blueprints for conversion.

To Save the Snow Leopard — Rodney Jackson

In the snow-covered Nepalese Himalayas lives the elusive, endangered snow leopard.

Mr. Rodney Jackson, a wildlife biologist, plans to capture live several specimens of these magnificent creatures and collar them with radio transmitters. Very little is known about the snow leopard, but we do know that it faces almost certain extinction as man encroaches upon its habitat.

Mr. Jackson's 1981 Rolex Award for Enterprise will expand our knowledge of the snow leopard and its environment and help save a beautiful species from extinction.

Preserving Mexican Folk Music — Eduardo Llerenas

The culture of Mexican folk music is one of the richest in the world.

However, due to the influence of TV, radio and the record player, it is a culture fast disappearing.

With two companions, Mr. Eduardo Llerenas has made over eighty trips into the remotest parts of Mexico in order to record, compare and preserve the country's traditional songs.

When completed, the work of Mr. Llerenas will provide an accurate and lively record of the folk music of Mexico.

His 1981 Rolex Award for Enterprise will help Mr. Llerenas to complete this valuable undertaking.

Re-fertilizing the Earth — Andre Martin

All over the world, vast tracts of fire-damaged land lie waste. To return land such as this to its original fertility is the aim Andre Martin has set himself. The undergrowth, brushwood and scrub, the only things which will grow on such land, are cleared and converted into an organically rich compost.

In a successful experiment in France, twenty previously desolate acres have been returned to successful cultivation using this method.

His 1981 Rolex Award for Enterprise is reward for Andre Martin's truly fertile imagination.

Let the Sperm Whale Live — Milan Mirkovic

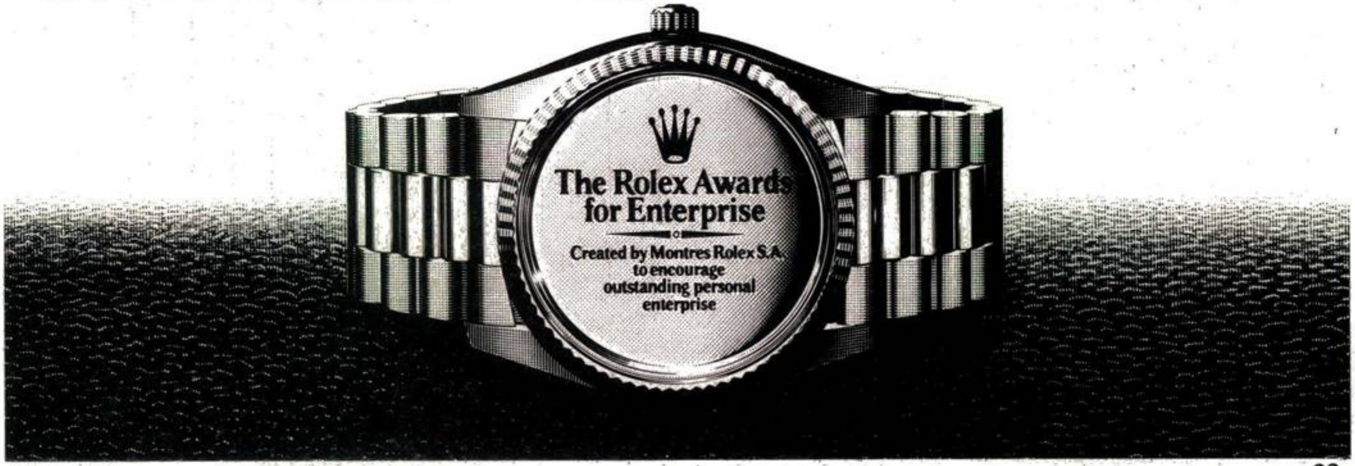
Mr. Milan Mirkovic has devised a novel irrigation method for the growing of the jojoba bush. The jojoba nut contains an oil which is almost identical in properties to sperm whale oil and therefore could become a commercial alternative to sperm whale slaughter.

However, it is only Mr. Mirkovic's use of containers filled with earth and a water absorbent polymer (it holds 1,000 times its own weight of water, thus dramatically reducing the cost of irrigation) which may make the cultivation of the jojoba a commercial possibility. Mr. Mirkovic's 1981 Rolex Award for Enterprise should help in saving the sperm whale.

Each of these five winners has received 50,000 Swiss francs as a contribution to the fulfillment of his work. Each has also received a specially inscribed Rolex Oyster as a tribute.

The 1981 Rolex Awards for Enterprise: Help and encouragement to those who have demonstrated truly outstanding enterprise.

ROLEX
of Geneva


The Rolex Awards for Enterprise
Created by Montres Rolex S.A. to encourage outstanding personal enterprise

ASTRONOMY FORUM

Come Explore A Comet

It sounded crazy: Raise a million dollars in donations to support the collection and analysis of data from the Viking 1 lander. Critics repeatedly told us that the public doesn't care about space and certainly doesn't care enough to give money for a robot gathering routine meteorology data on Mars.

But within a month after we announced the Viking Fund, 3,000 people proved the critics wrong by digging into their wallets to help pay for their space program. Six months later, the number of contributors had grown to almost 7,000.

On January 7 of this year, the Viking Fund gave its first contribution — $60,000 — to NASA. Never had the pro-space movement so vividly shown its support for a renewed space program.

Comet Halley, June 7, 1910. Lick Obs. photo.

Now we must capitalize on what the Viking Fund began — private citizen support of the space program. Year after year, new programs have been cut from the NASA budget while existing programs are delayed. Another four years of neglect will leave NASA an empty shell. There is no hope that politics-as-usual will revitalize the space agency — instead we must involve ourselves and push for the new projects NASA needs.

Nowhere have short-sighted funding cuts had clearer effects than with a proposed mission to explore Halley's Comet. For two millennia, this comet has been part of our culture and history. Despite those years, Halley is a very young comet, on an astronomical timescale. It is, in fact, the freshest comet we know with an orbit we can predict. Astronomers believe that if we are to understand comets — and hence the origin of our solar system — we must explore at least one comet, and Halley is perfect for such study. The Soviets, Europeans, and Japanese all understand the importance of Halley and are readying spacecraft for flybys in 1986.

Twice NASA has asked for a U.S. mission, and twice the budget cutters have said no. They rejected the missions — costing each of us taxpayers only $2 to $3 apiece — because NASA seemed an easy place to trim an otherwise ballooning federal budget. Now their actions, unless reversed, will cause America to lose out on valuable scientific knowledge, new technologies, and quite a bit of prestige.

Time still remains to begin work on a U.S. Halley Intercept Mission (HIM). By itself, HIM would guarantee close examination of every major aspect of this comet. HIM is a mission superior to the other Halley missions — and could

CT-100

The Telescope to start with
The system to grow with

SHOWN WITH OPTIONAL TRIPOD

The World's
- ★ **Most Versatile**
- ★ **High Quality**
- ★ **Super Portable**
- ★ **Easy to Use**
- ★ **Lowest Cost**

4¼" Telescope System

Do you want to hunt comets, roam the Milky Way, locate other galaxies, and see exciting nebulae? Then start with our Basic CT-100 f/4 Telescope for real eye openers to the universe.

Now or later add our optical erecting prism and return to earth for vivid focal adventures from infinity down to 4'.

If lunar/planetary observation is your special interest, then our f/8 Converter will add a second telescope to maximize your enjoyment of the CT-100 System.

Optional eyepieces, various mounts, camera adapters, and a finder scope are also available.

So go for the CT-100 System to get the *world's best buy* in astronomical and terrestrial telescope versatility. Only $99.50 *now* including case for the Basic CT-100 f/4 ($119.50 for orders postmarked after July 31.)

When One Telescope Isn't Enough . . . With Options It Becomes . . .

A LUNAR-PLANETARY SCOPE

AN ASTROGRAPHIC CAMERA

A TERRESTRIAL TELESCOPE

Quality Optics for Astronomy

ASTRONOMICAL MIRRORS

These mirrors are recognized as the finest, yet lowest priced, on the market. They meet the most demanding specifications. The mirrors are made from fine annealed Pyrex blanks with a 1:6 thickness ratio. Aluminized and silicon monoxide coated, null figured. Satisfaction guaranteed.

6" f/5	$57.50	10" f/5.6	$121.50
6" f/8	45.95	12½" f/6	229.50
8" f/6	79.50		

ELLIPTICAL DIAGONAL FLATS

These coated flats are ready to mount and use. Choose minor axis below.

0.75"	$6.95	2.14"	$18.95
1.30"	$9.50	2.60"	22.50
1.52"	13.50	3.10"	34.50
1.83"	15.50		

COULTER KITS

4¼" RFT	$39.50
5" f/3 Lensless Schmidt Camera	99.50
Performance Kit	7.95

CT-100 System and Astronomical Optics prices include shipping in the 48 contiguous States. Shipping costs are additional for other destinations. *CALIFORNIA RESIDENTS ADD 6% SALES TAX*

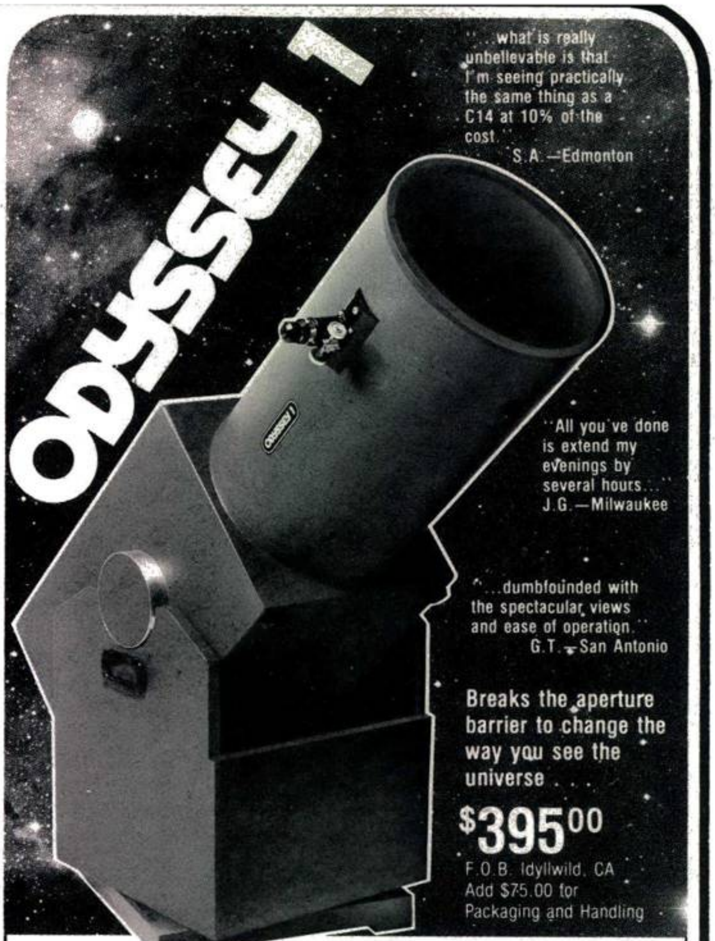
VISA and MasterCard Accepted

Visit our Showroom at 54141 Pinecrest Road
Showroom Hours Mon.-Fri. 8-4:30 Sat. 12-4

Write for Free Literature to:

Coulter Optical Company

DEPT. A BOX K IDYLLWILD, CA 92349
TELEPHONE 714 659-4621



"...what is really unbelievable is that I'm seeing practically the same thing as a C14 at 10% of the cost."
S.A.—Edmonton

"All you've done is extend my evenings by several hours..."
J.G.—Milwaukee

"...dumbfounded with the spectacular views and ease of operation."
G.T.—San Antonio

Breaks the aperture barrier to change the way you see the universe . . .

$395⁰⁰

F.O.B. Idyllwild, CA
Add $75.00 for Packaging and Handling

Since Lord Rosse discovered the spiral structure of M51 through his 72" Leviathan of Parsontown in 1845, few amateur astronomers have been able to afford instruments which enabled them to share his excitement and pleasure. Now the 13.1" aperture of Odyssey I bridges that 136-year *performance gap* to reveal the universe more vividly than ever before at such modest cost. Priced in the range of most 8" telescopes, Odyssey I clearly shows the spiral arms of M51. It brings out color in the Orion Nebula, shows the dust lanes in the Andromeda Galaxy, lets you see the elusive Veil Nebula, reveals thousands of NGC objects, and provides intricate lunar/planetary detail.

SPECIFICATIONS

13.1" dia. f/4.5 paraboloidal Pyrex mirror, null figured aluminized and coated. ☐ 3.1" minor axis elliptical diagonal flat $\frac{1}{10}$ wave aluminized and coated. ☐ 9 pt. flotation system. ☐ 3 pt. collimation adjustment. ☐ 25mm coated Kellner eyepiece with 1¼ rack-and-pinion focuser. ☐ Dobsonian alt-azimuth Mount. ☐ Anti-backlash Teflon bearings throughout for smooth operation. ☐ Blue Zolatone finish. ☐ Ready to use. ☐ Weight, 120 lbs.

Build Your Own Dobsonian

Now it is possible to build an observatory class deep sky telescope at a reasonable cost by using this set of optics and utilizing Dobsonian technology. The performance increase of 17.5" of aperture produces a dramatic new dimension in observing. Literally every N.G.C. object can be detected. Faint undefinable objects become objects of major interest. There is no better way of increasing your interest and enjoyment in observing deep sky than to increase aperture. 17.5" dia. by 1½" thick, Null figured paraboloidal Pyrex mirror. 4.25" Pyrex flat, both coated. Includes useful data.

17½" f/4.5 OPTICS

$595⁰⁰

provide answers that the others, combined, may not.

Time is short. NASA needs $40 million this year and a formal commitment next year from Congress if HIM is to fly. And at $250 million, HIM is one of the cheapest deep-space probes ever proposed by NASA. Adding the mission would increase the agency's funding by less than 1%, but the politicians still drag their feet.

As Director of the Halley Fund, I believe we can be instrumental in getting a U.S. Halley mission off the ground. Key members of the scientific and pro-space community serve on the Halley Fund advisory council and are assisting us in this 11th-hour effort: Dr. Michael J.S. Belton, of Kitt Peak National Observatory, vice-chairman of the Division of the Planetary Sciences of the American Astronomical Society; Richard Berry, editor of ASTRONOMY magazine; Robert Petrey, publisher of *Star & Sky*; Leif Robinson, editor of *Sky and Telescope*; Bjo Trimble, of Citizens for Space Advocacy; Dr. Joseph Veverka of Cornell University, and chairman of NASA's Comet Science Working Group; and Dr. Fred Whipple, director emeritus of the Smithsonian Astrophysical Observatory, and the man responsible for modern scientific comet theory.

But the Halley Fund has one thing even more important than an advisory council — it has people behind it: the ten thousand who have given money to support a five-year-old Mars lander. We think even more, maybe tens of thousands, will give to save a once-in-a-lifetime odyssey to Halley's Comet.

Each person who sends a donation to the Halley Fund will register his vote for the mission in a medium politicians understand: money. That money, however, is more than just a statement of belief. Later this year, the fund's advisory council will help us select one or more projects proposed by American scientists to study this comet. Since NASA has no money appropriated to buy equipment for the study of Halley, the fund can make a crucial difference in the contributions Americans make in researching this object. A few tens of thousands of dollars could buy the filters needed to examine Halley from an Earth-based observatory. A few hundreds of thousands of dollars could buy the flight of a UV telescope to study Halley from the Shuttle. A million dollars or more could buy an instrument for a spacecraft going to Halley.

Let's make the Halley Fund the battle cry for those of us who want to see our political process develop the resolve to revitalize NASA. Come explore a comet...and save our space program.

Please send your tax deductible contribution to the Halley Fund, Dept. AS, 357 Saratoga Ave., Santa Clara, CA 95122.

Van R. Kane, Director
The Halley Fund

Bruce Murray on the Future of America in Space

On March 21, 1981, Dr. Bruce Murray, Director of the Jet Propulsion Laboratory, testified before the Space Science and Applications Subcommittee of the U.S. House of Representatives' Committee on Science and Technology at JPL headquarters in Pasadena. The following is a transcript of his testimony.

Mr. Chairman, members of the subcommittee: I appreciate the opportunity to discuss with you the status and the future of the U.S. deep space exploration program and, relatedly, the future of the Jet Propulsion Laboratory.

Frankly, Mr. Chairman, the U.S. deep space program is in jeopardy and even may face extinction. Despite the widespread popularity and national significance of our remarkable deep space effort, this nation's unique capability to explore the solar system is fast eroding and approaching collapse.

The Galileo Jupiter Orbiter and Probe has been delayed three years by the Shuttle Orbiter and upper stage development problems. It remains vulnerable even now to any delay in initiating serious development of the planned Centaur upper stage.

The Venus Orbiting Imaging Radar mission has again been slipped from the planned 1986 opportunity until 1988. It is farther from realization now than it was four years ago.

There is no Mars program to follow Viking, although extensive studies have investigated roving vehicle and sample return possibilities.

Only the United States, among those nations with even a modest space exploration capability, has no plans to mount a Halley's Comet mission.

And finally, for the first time since NASA was formed 22 years ago, a well-managed, well-established scientific and exploratory mission — the U.S. part of the International Solar Polar Mission — is being canceled outright, international agreements notwithstanding.

It is ironic that such a list of negatives should be the issue at this hearing in this place. Today, in other rooms nearby, JPL engineers are preparing Voyager 2 by remote control for its upcoming encounter with Saturn on August 25. Last November, Voyager 1 held the attention of the world as it made its dramatic excursion through the Saturn system. People everywhere responded to the adventure and to the splendor of the discoveries and admired the United States' technological excellence. Not since Apollo, a decade ago, have U.S. citizens and the people of the world been more captivated by a space expedition. Voyager truly is an example of how America's deep space exploration program can properly earn the world's respect and admiration, as well as symbolize to our own people their aspirations for our nation's future.

Exploratory missions like Voyager not only have unquestioned value to U.S. prestige around the world, but are among the most important scientific endeavors of this century. Furthermore, as a by-product, such endeavors can have broad space technology implications. For example, Voyager must operate without frequent ground support because the round-trip time alone for radio signals at Saturn is nearly three hours; conventional ground intervention and monitoring is simply not possible. As a result, Voyager is designed to survive a variety of failures and still function correctly. Further, it is necessarily radiation-hardened for protection during its passage through Jupiter's potent radiation belts. The demonstrated Voyager reliability in a high-radiation environment and especially its advanced autonomy features are two attributes required also by future defense satellites. As a result, during 1980, JPL embarked on an important new autonomous spacecraft task for the Air Force, at their request, to help create new defense space systems which can perform their intended missions even if their ground control stations become unavailable.

Yet Voyager could go into the history books as the last grand achievement of a once-vigorous U.S. civilian space exploration program which contributed so heavily to our country's scientific and technological

GLOBES FROM ASTRONOMY

Beautiful additions to your home, office, classroom or library. Accurate and sturdy, they are made by Replogle, the world's largest manufacturer of fine globes.

The Apollo

12" celestial globe shows 1,200 stars to 4th mag. Includes clusters, novae, doubles and the Milky Way! Gyromatic mounting in silver finish, complete with illustrated booklet.

16½" high **$24.95**

NASA Moon Globe

Official 12" globe with NASA-approved detail! Extremely accurate, it is strikingly 3-dimensional, rests on a molded base and comes complete with booklet and study projects.

15" high **$21.95**

The Lenox

Beautiful 12" raised relief globe with parchment effects, cartouches and compass roses giving an elegance and charm to any room. Antiqued fruitwood finish on base and half meridian ring.

18" high **$35.00**

- To Order Use Form Between Pages 60-61.
- Orders Outside North America subject to Extra Shipping Charge. Contact ASTRONOMY for Details.

Looking... for the right price on a quality telescope or accessory?

You just found it!

Before you buy a telescope or accessory from *anyone,* send for our *free* discount price list of more than 70 telescopes and 500 accessories — or send a stamped (52¢ postage) self-addressed envelope for information-packed catalogs describing all the equipment and telling how to pick the right telescope and accessories, and much, much more!

Celestron, Meade, Questar, Unitron, Edmund, Quantum, Brandon, TeleVue, DayStar, University...and others!

Ad•Libs Astronomics

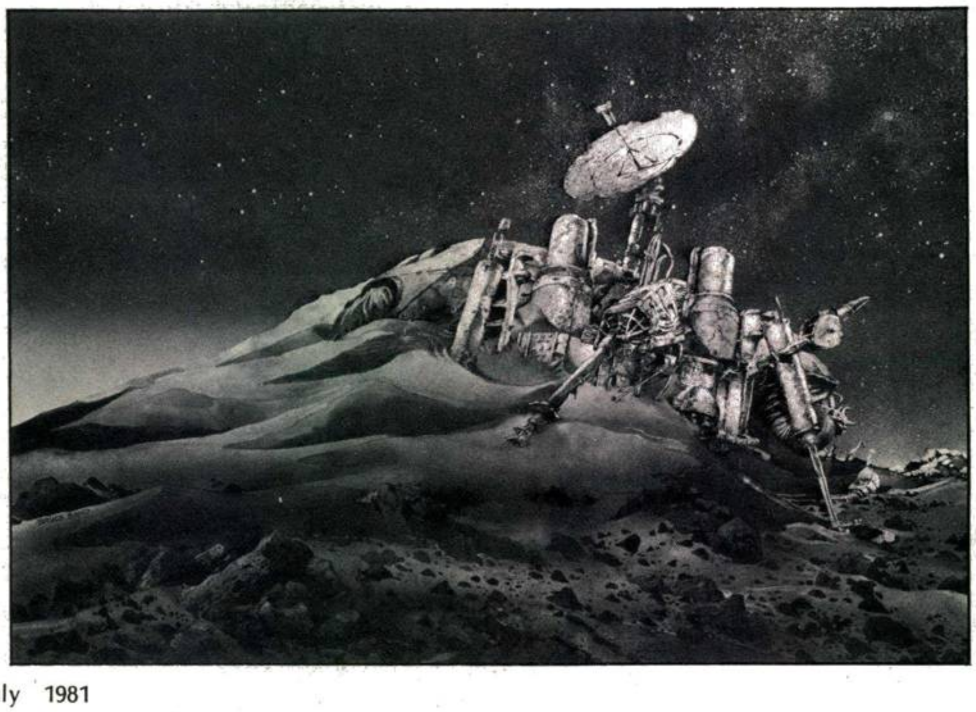
2140 Melrose Court, Norman OK 73069

(405) 364-0858

master charge VISA

© 1981 by Ad•Libs Advertising, inc.

Add Planetary History to Your Poster Collection



Viking at Mars... 500,000 A.D.

Its instruments dead, the men and women who built it forgotten, the blind and pitted hulk of Viking 1 — once a tribute to mankind's technology and pioneer spirit — stands as a lonely memorial to humanity's flirtation with planetary exploration.

This poster is made from the original painting used to illustrate "Mars 5 Years after" in this issue of ASTRONOMY. See the photo spread on pages 6 and 7.

Full Color 24" x 36" $7.95

to order see pages 60-61.

base, provided an economic stimulus for a number of U.S. industries and enhanced our national spirit and international respect. We're running out of time to preserve the rapidly diminishing NASA/industry capability for solar system exploration.

Consider the precipitous decline in U.S. deep space capability within the last five years. The Langley Research Center, which teamed with Martin Marietta to develop the 1975-78 Viking Mars Lander mission (and with Boeing for the Lunar Orbiters of the 1960s), is entirely out of the deep space business. Ames Research Center and TRW developed and flew the Pioneer Jupiter-Saturn in the early 1970s; the same Ames team worked with the Hughes Aircraft Company to design and carry out the 1978 Pioneer Venus orbiter and probes mission. Ames is currently reduced to the more specialized role of developing an atmospheric probe (with Hughes) as part of JPL's Galileo mission. And of course, TRW, JPL's industrial partner for the NASA spacecraft portion of the Solar Polar mission, is being wound down right now as a result of the cancellation of the U.S. ISPM spacecraft.

JPL, NASA's lead center for deep space exploration, maintained for 15 years two fully integrated flight project teams capable of bringing state-of-the-art projects along in an orderly sequence — one expanding while its predecessor was phasing down. Since completion of the Viking Orbiter development efforts in 1975 and the launch of the Voyagers in 1977, there is only a single team currently at full strength. And that team has had the challenging and somewhat demoralizing task of pursuing the Galileo Jupiter mission design and implementation through repeated delays and threats of cancellation.

I believe this decade will surely witness America's abdication as the world leader in space exploration unless you and your colleagues in Congress do something about it now. The legislative process this year must help keep our deep space options alive — and a valuable national asset preserved — until a fully constituted Executive branch will have the necessary time to set new priorities in space. I expect that process ultimately to strongly emphasize visible U.S. leadership in space, a function served so cost-effectively by Voyager-like endeavors. In the meantime, we must avoid further setbacks, from which recovery would be next to impossible, pending development of a normal process through the next budget cycle.

Let us now examine the current status of the deep space program and consider measures to cope with threats to its existence:

The Galileo mission to Jupiter will send a spacecraft into orbit around the giant planet and begin a prolonged examination of its weather systems, its turbulent magnetosphere, and its diverse collection of moons. Galileo will also send an instrumented probe into the jovian atmosphere. The NASA Ames Research Center is responsible for the probe, as part of the project managed by JPL.

Galileo, now planned for launch in 1985, after schedule slips and configuration changes due to the launch vehicle troubles, is an approved project with scientific experiments and all engineering work nearing completion. Keeping Galileo and the Shuttle-Centaur development essential for its launch on track for 1985 is critically important.

The International Solar Polar Mission (ISPM), intended to make unique observations of solar phenomena from above and below the plane of the solar system, employs two spacecraft: one European and one American, launched to Jupiter where that planet's huge gravity flings them into trajectories passing over the poles of the Sun.

ISPM, a project approved by both the European Space Agency (ESA) and NASA for launch in 1985, has also experienced delays and revisions due to the launch vehicle situation, but now it is threatened more seriously.

NASA, within the various budget constraints provided by the Office of Management and Budget, has found it necessary to recommend that the U.S. spacecraft be terminated and only the European spacecraft be launched by the Shuttle-Centaur in 1986. However, NASA will support other elements of the project on a 1986 basis consistent with the NASA/ESA Memoranda of Understanding. It now appears that if proper steps are taken promptly by all concerned, the FY '82 budget reductions do not necessitate an immediate foreclosing of various ISPM 1986 opportunities.

The Venus Orbiting Imaging Radar (VOIR) mission is now rescheduled for launch in 1988. The spacecraft will carry a mapping radar and a high-capacity data system into Venus orbit to obtain images of the permanently cloud-shrouded venusian surface. The high resolution global radar coverage will open up the planet and its geological processes to our eyes as did Mariner 9 and Viking Orbiters at Mars. NASA's present FY '82 budget plan provides funds to maintain VOIR progress toward a 1988 launch. This will allow time to carry out all of the preparatory work leading to a particularly thorough project definition, thus providing assurance that the project will go as planned.

A most distressing omission from the current U.S. program is an opportunity to lead the world in exploring Halley's Comet. In 1986, the famous comet will make its first appearance since 1910 and won't return for another 76 years. We are running out of time to take advantage of this unique opportunity even as our major space competitor is apparently increasing planned efforts to supplant traditional U.S. deep space leadership by focusing on the Halley opportunity.

I believe that what is happening to the deep space exploration program in the United States and its supporting institutions is inconsistent with the priorities and processes that led to such missions as Voyager; it is inconsistent with the wishes of the American people; and it is inconsistent with the stated policy of all currently concerned.

If taken at face value, it would seem that some recent actions were a conscious effort to dismantle the deep space capability of this country. But I know that it is no one's intent or policy for America to quit the exploration of the solar system.

I would ask the Congress to deal effectively with this unnecessary loss of our nation's capability and leadership in space by doing the following:

- Support all necessary measures to get Galileo and Centaur off on a fast start for a 1985 launch.
- Strongly support the continuance of ISPM 1986 options, including those with some version of a U.S. spacecraft at least through FY '81 and early FY '82, pending a final decision in the FY '83 budget cycle.
- Maintain VOIR on the present schedule, leading to launch in 1988.
- Endorse the desirability of a U.S. Halley Intercept Mission and strongly encourage NASA to at least keep that option open through the next budget cycle when the new Administration can properly consider it.
- Offer strong support to NASA's incoming management team in efforts to develop a rejuvenated deep space exploration program.

Thank you, Mr. Chairman. This concludes my testimony. I will be happy to answer any questions.

IMITATED
BUT NOT YET
EQUALLED

RV-6
6-INCH
DYNASCOPE®

There Is Simply Nothing Like It At Anywhere Near Its Price

Including . . . Electric Drive, 2 coated eyepieces (threaded for filters), setting circles, 6x30 finder, rotating tube and more.

See For Yourself Why This Famous RV-6 Dynascope May Well Be The Most Popular 6-Inch Telescope In The World Today

More amateurs, professionals, schools and colleges have bought it, used it, recommended it and endorsed it than any other kind. It has been proven in use far beyond any other.

Recognition of the RV-6 among schools, colleges, professionals and expert amateur astronomers is beyond question. No other instrument of its kind has been more proved in use or more widely praised and enthusiastically accepted. Thousands upon thousands of RV-6 Dynascopes prove our engineering leadership. Certainly, more 6" Dynascopes are in use throughout the world today than any other competing model.

Yes, there must be good reasons why more people have chosen it, more experts endorse it than any other 6" Newtonian. And the reasons for its overwhelming Number One rating are simple: more quality, more performance, more value.

Consider, for instance, the superb optical system accurate to better than 1/10 wave, which flawlessly resolves even the most difficult objects with breathtaking ease. Or the heavy duty equatorial mount in which all castings are precision machined to better than .001," providing the stability so necessary for satisfactory viewing and long exposure astrophotography. Because of superb design and precision construction, the entire instrument is as completely rigid and wobble-free as it is simple and easy to use. All materials, long tested in field use, meet extreme durability standards—right down to our new solid stainless steel declination shaft which cannot rust even through a lifetime of use. In comparing value, what other telescope in this price range offers the everlasting quality and close tolerances of solid stainless steel? Or the extra value of Achromatized Symmetrical eyepieces of Plössl quality (superior to both Ramsden and Kellner types), whose brass barrels are threaded to accept filters? Then again, what other telescope in this price range or higher offers you a *one year* unconditional guarantee of satisfaction to back up its advertising claims?

Yet, modern production engineering holds the costs to levels that permit our remarkable price of $279.95, complete—not for a "stripped" model, but for the fully equipped RV-6 Dynascope that has won such unprecedented user pride and loyalty. You can order your RV-6 today with complete confidence that it will live up to your expectations in every way, or we will refund every cent you paid under our unique unconditional money-back guarantee. Send your check or money order today.

You Could Pay $100 More Without Getting All These Superior Features
(Except on Another Dynascope)

1. **Exquisite Optical System**—Includes f/8 6-inch parabolic mirror accurate to better than 1/10 wave, zircon quartz coated, guaranteed and proven in use to be the finest 6-inch Newtonian optical system obtainable—even when compared to 6-inch telescopes costing far more.
2. **New Dyn-O-Matic Electric Drive** with smooth self-acting clutch that engages and disengages automatically as you seek different objects. Will not interfere when manual operation is desired. Safety housed case. Plugs into ordinary AC socket.
3. **Two High Performance Eyepieces**—70X (18 mm.), Symmetrical; 140X (9 mm.), Symmetrical, 1-1/4" dia., precision threaded, coated. Also available, extra Symmetricals: 40X (30 mm.), $22.50; 100X (12.7 mm.), $22.50; 180X (7 mm.), $22.50; 220X (6 mm.) Orthoscopic, $25.00; 320X (4 mm.) Orthoscopic, $25.00; 16.3 Erfle Wide Angle, $30.00; CP4 Achromatic Barlow to triple powers, $18.50. All give sharpest images to extreme edges. Brass barrels of all Criterion eyepieces are threaded for filters.
4. **Solid New Equatorial Mount**—Precision machined to better than .001", assuring pillarlike stability during observation or long exposure work. No annoying side play or wobble. Solid Stainless Steel Declination axle can never rust, unlike other 6-inch telescopes. Adjusts easily to any latitude.
5. **Setting Circles** for both Right Ascension and Declination. Handsomely engraved and finished in fine aluminum. Read directly into the sky for easy acquisition of faint objects.
6. **6x30 Finderscope, Achromatic, Coated,** with accurate crosshairs and precision micrometer screw focus. Focus "stays put" unlike sliding draw tube spy-glass types. 6 adjusting screws provide positive collimation.
7. **Rotating Rings for Maximum Versatility and Viewing Comfort**—Solid-cast, chrome finish, rings are generous 1" wide with felt lining. Newly designed construction, with over-sized knurled adjusting knobs, affords maximum rigidity and allows for quick disassembly and portability, with or without tube.
8. **Strikingly Handsome, White 50" Bakelite Tube** with porcelainized Duralite finish, durable yet light. Walls are 1/8" thick, completely insulated and anti-reflective blackened inside. Dimensionally stable, maintains perfect collimation at all times.
9. **Brass Rack-and-Pinion Eyepiece Holder** has precision-cut worm and gear for easier, smoother, more positive focusing. Takes standard 1-1/4" oculars, negative or positive.
10. **Strong, Vibration-Free, All-Metal Tripod** with easily removable legs. Provides sure, steady support, plus lightweight portability.
11. **Excellent Photographic Capabilities**—Factory settings for both prime focus and eyepiece projection astrophotography are included upon request at no extra charge! Superb lunar, planetary and deep space photos are easily obtainable by the average amateur.
12. **Optional Accessories**—A complete system of optical accessories is available to cover the amateur's every need, including drive correctors, camera adapters for both prime focus and eyepiece projection work, eyepieces, filters, and more.

CSi **Criterion Scientific Instruments**
620 Oakwood Ave., West Hartford, Conn. 06110
Manufacturers of Quality Optical Instruments **203-247-1696**

Model RV-6 Complete with Dyn-O-Matic Electric Drive and All Features Described Below

$359.95

F.O.B. Hartford, Conn.
$15 Crating Charge

Back By Popular Demand . . . Model RV-8

Identical to the RV-6, but includes a manual declination slow motion, longer declination axle, extra counterweight and of course an 8" f/8 optical system.

$459.95

$15 Crating Charge

PROOF IS IN THE USING —OUR GUARANTEE

When comparing telescopes, be sure to compare guarantees. Be cautious of guarantees whose time limit does not permit ample time to thoroughly evaluate the telescope. For instance, a new telescope owner may frequently require several weeks or more to get used to his instrument before a defect is found (remember also that atmospheric conditions may prevent optical testing for long periods of time). For this reason, we give you a *one year* unconditional money-back guarantee. During this period, if you find the RV-6 is not everything we advertise it to be, if it does not measure up to other 6" telescopes you compare it to, or if you are simply dissatisfied with your purchase in any way, you can return the instrument for a full refund. Our guarantee is your assurance that the RV-6 is the best 6" Newtonian you can buy.

Criterion Scientific Instruments
Dept. 102, 620 Oakwood Ave., West Hartford, CT 06110

☐ Please send me, under your unconditional guarantee, the RV-6 6-inch Dynascope. Payment of $279.95 plus $15.00 crating charge is enclosed.

☐ Please send me, under your unconditional guarantee, the RV-8 8-inch Dynascope. Payment of $459.95 plus $15.00 crating charge is enclosed.

☐ Charge to my credit card
☐ American Express ☐ VISA/BankAmericard ☐ Master Charge
Card No.________________ Expiration Date________________

☐ Send FREE ILLUSTRATED LITERATURE describing the RV-6 6-inch Dynascope and all other telescopes in the Dynascope line.

☐ Send FREE ILLUSTRATED LITERATURE on your new DYNATRACKER Variable Speed Control for RV-6 or other electric drive telescopes.

Name (Print)________________ Signature (If credit card)________________
Address________________
City________________ State________________ Zip________________

eye
on the
sky

the great conjunction: act III

by
Fred Schaaf

the wanderers

In the past two years, planetary observers have been blessed with an awesome number of splendid conjunctions. And this fertile period is not over yet — not quite. The next few months, which also feature an eclipse and great meteor shower, will be a fitting conclusion to two years of glorious conjunctions and gatherings of the planets.

One of the prime astronomical events of July 1981 is a partial eclipse of the **Moon** on the night of July 16-17. (For a full story on the eclipse, see this month's Gazer's Gazette.)

Even this month's lesser celestial events are extremely interesting. **Mercury** has a fairly good apparition in the predawn sky, reaching a greatest elongation of 21° on the 14th. It brightens to -0.8 by the morning of the 26th. The elongation will have decreased to 15°, but the planet is close to 3.5 magnitude Delta (δ) Geminorum (Wasat). About seven hours later, Mercury passes just 13′ north of the star. When Mercury is near greatest elongation, it almost ascends to catch the far dimmer Mars, which shines close above Mercury on those mornings. In early July, red **Mars** is passing between the horn-tips of Taurus and, at about magnitude 1.7, is a twin for the nearby Beta Tauri (El Nath).

Venus is involved in several important conjunctions in July. On the evening of July 3, our "sister" planet is just 29″ north of 5.5 magnitude Eta Cancri, but this is so close and with such a brightness difference that you'll need a telescope to distinguish the two. Binoculars or clear skies for your unaided eyes may be enough to help you see the Beehive cluster nearby that night. And, if the clear skies continue, you'll see Venus on the eastern edge of the cluster the next evening. Do these conjunctions sound too difficult? Then just wait until the evening of July 23 (when Jupiter and Saturn are nearest each other) to see the -3.3 magnitude Venus pass just 1.2° north of first magnitude Regulus, the heart of Leo. That will be a night of not just one, but two brilliant pairings.

Another event to remember in July is the closely coinciding appearance of the broad peaks of the **Delta Aquarid** and **Capricornid** meteors at month's end (when the Moon is new). These will be a prelude to a possibly awesome **Perseid** peak in August (the Perseids are already beginning as July draws to a close).

Observers in Siberia and the North Pacific will see one of the great astronomical events of their lives when they behold, at the end of the month, a total eclipse of the Sun. But for most of us, the great event of July (along with the lunar eclipse) will be the final meeting in the **Great Conjunction** of **Jupiter** and **Saturn**.

All month, Jupiter is in hot pursuit, as planetary speed and observational interest both increase until Jupiter brushes remarkably close to two stars as a prelude to the main event.

The giant planet, shining at about -1.4, goes only 6½′ north of 13 Virginis (magnitude 5.9) during the day of July 19 for North America — so look for very close pairings the night before and after, and have binoculars handy (there will be a nearly Full Moon). The next conjunction will be better and almost perfectly timed for the U.S.: Jupiter will be just 9′ south of Eta (η) Virginis at about 9 p.m. EDT on the 21st. Since Eta is 4.0 magnitude, this is a chance to test your naked eye on a sight which is somewhat easier to see than Ganymede and Callisto — but still notable to accomplish. The sight in binoculars and telescope should be quite beautiful (like a brilliant fifth Galilean satellite), and once again, the nights before and after will offer gorgeous and easy naked-eye views.

On July 23, Jupiter and Saturn are closest to each other for the third time over a period of 7 months — this time they are 1°06′ apart. But it is not until July 30 that Jupiter passes 1°12′ south of Saturn for the third and final conjunction in right ascension. Jupiter and Saturn will not meet again until 2000, when they'll have a single twilight conjunction near the Aries-Taurus border. This month's conjunction will occur just two days after Jupiter reaches aphelion (5.4535 AUs from the Sun), and it will mark the end of the Great Conjunction, which will not recur until the year 2238.

Though this month will see the official conclusion of the Great Conjunction, it will not be the end of these planets' involvement with each other. Before drawing far apart, Jupiter and Saturn will join in a series of spectacular groupings with Venus, the Moon, Mercury, and Spica! And the best is due next month.

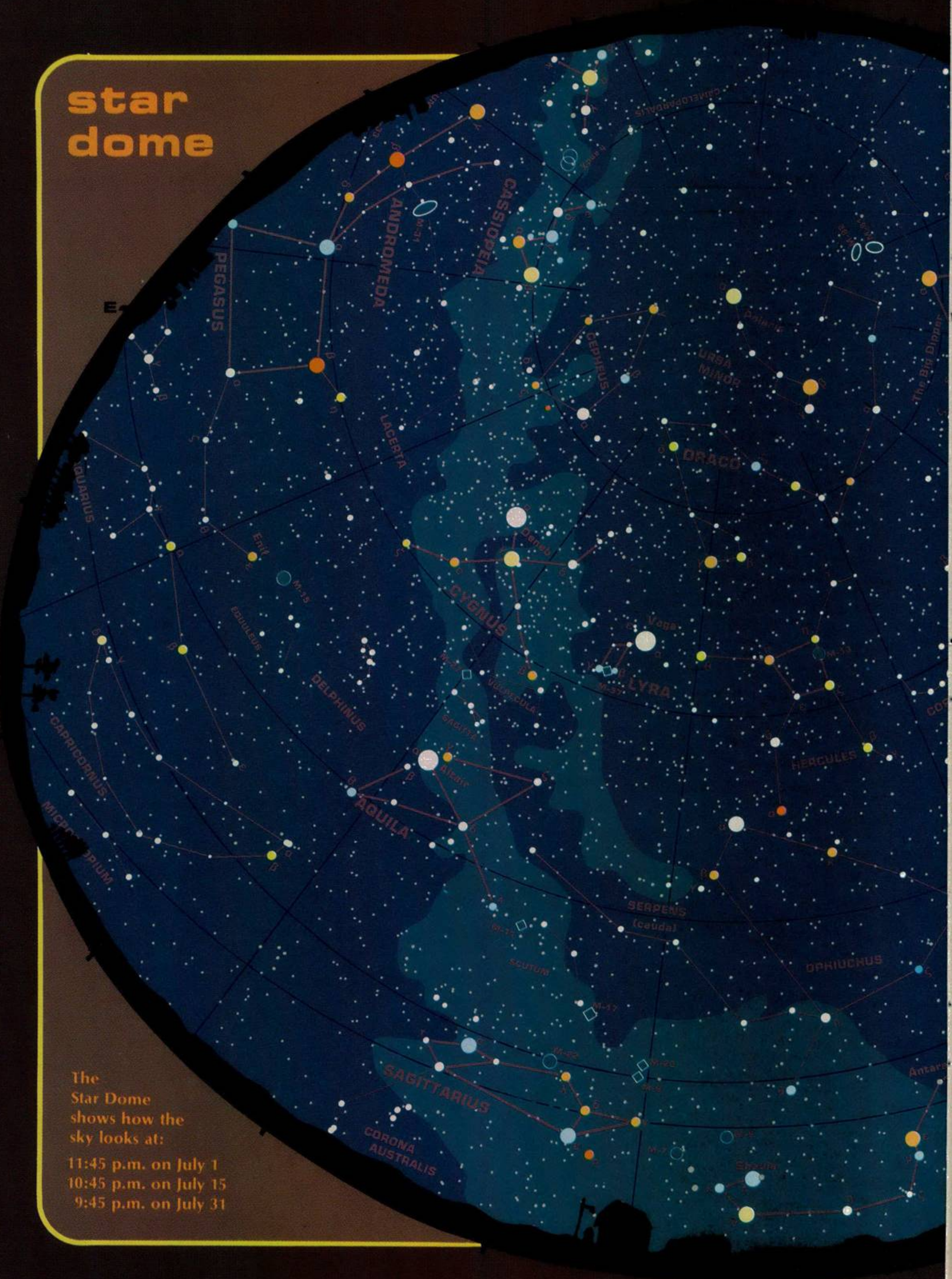
the starry sky

If we had to select a single constellation to represent the month of July, the choice would not be very difficult. At the end of evening twilight, by far the brightest and most prominent constellation on the meridian is the long, coiling form of **Scorpius** the scorpion.

The glittering scorpion's heart is the reddish first magnitude star **Antares**, whose name literally means "rival of Mars" ("anti-Ares" — Ares is the Greek name for Mars). The Red Planet can greatly outshine Antares, but

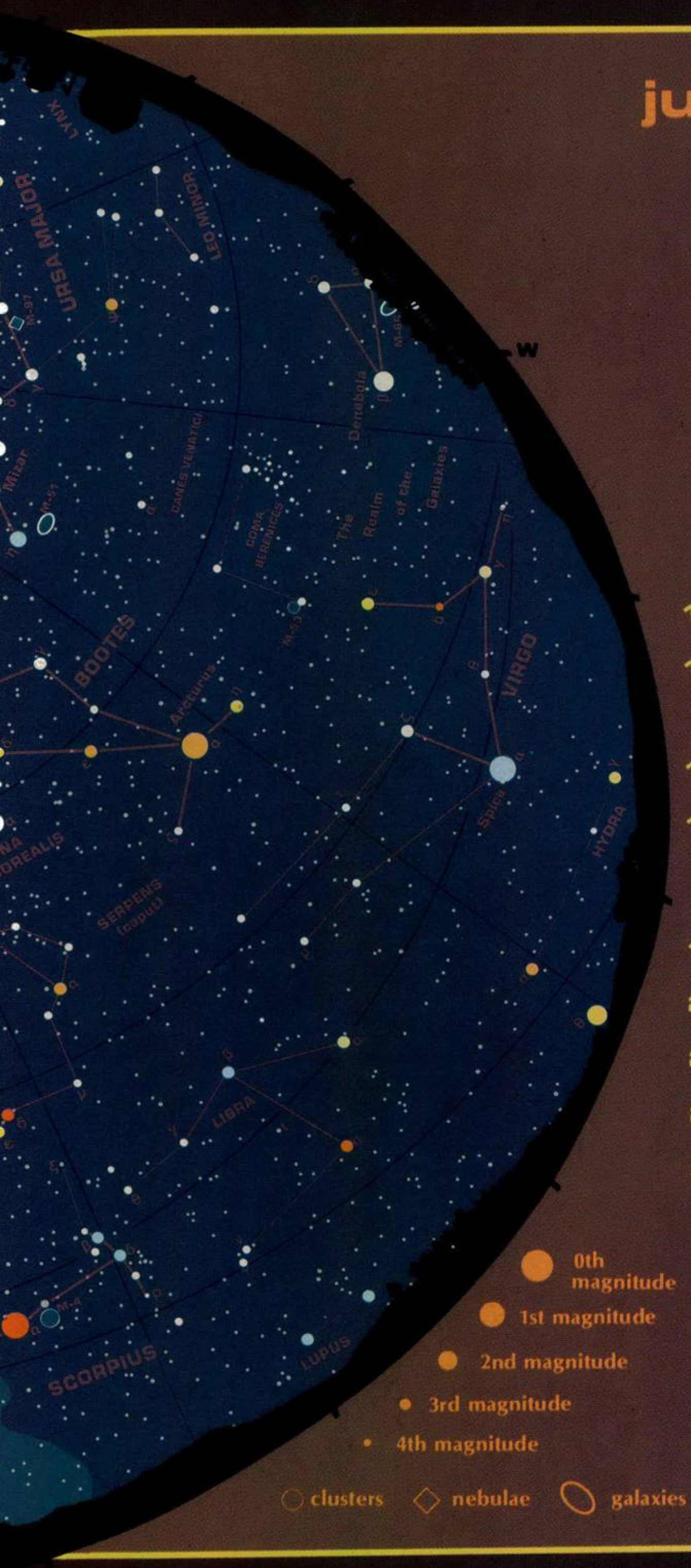
Summer, for many people, means an excellent chance to get away to dark skies — perhaps the only opportunity all year. You can't help the weather, but planning an *"observer's vacation"* could make a long-remembered summer. Nelson Chow's 2-hour exposure shows star trails and observers at Cape Croker, Ontario.

star dome


CAMELOPARDALIS
CASSIOPEIA
ANDROMEDA
M-31
PEGASUS
E
CEPHEUS
URSA MINOR
Polaris
The Big Dipper
DRACO
LACERTA
AQUARIUS
Enif
M-15
EQUULEUS
DELPHINUS
CYGNUS
Deneb
Vega
LYRA
M-57
M-13
HERCULES
VULPECULA
M-27
SAGITTA
Altair
AQUILA
CAPRICORNUS
MICROSCOPIUM
SERPENS
(cauda)
M-11
SCUTUM
M-17
OPHIUCHUS
M-22
M-20
M-8
SAGITTARIUS
CORONA
AUSTRALIS
M-7
M-6
Shaula
Antares

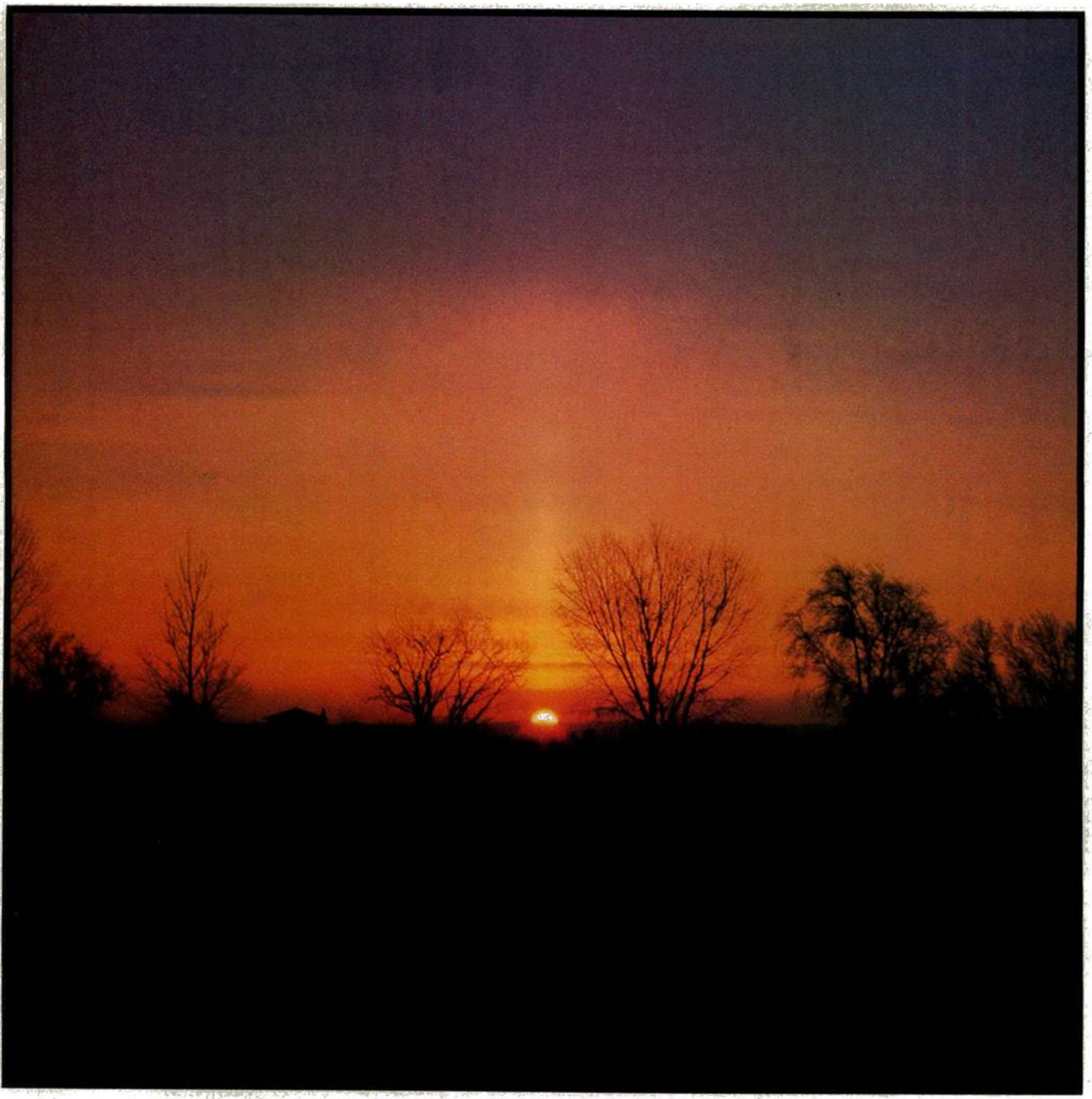
The Star Dome shows how the sky looks at:

11:45 p.m. on July 1
10:45 p.m. on July 15
9:45 p.m. on July 31


LYNX
URSA MAJOR
LEO MINOR
M-97
Mizar
M-51
CANES VENATICI
COMA BERENICES
Denebola
The Realm of the Galaxies
M-66
M-53
W
BOOTES
Arcturus
VIRGO
Spica
HYDRA
NA
OREALIS
SERPENS
(caput)
LIBRA
SCORPIUS
LUPUS
M-4
0th magnitude
1st magnitude
2nd magnitude
3rd magnitude
4th magnitude
clusters
nebulae
galaxies

july sky almanac

1st	New Moon comes at 3:03 p.m. EDT. For the next 5 to 7 nights, the sky will be dark — best for stargazing and constellation learning.
3rd	Earth is at aphelion (its farthest distance from Sun) at 7 p.m. EDT: 94.5 million miles. A crescent Moon lies near Venus tonight.
4th	Venus will lie just to the east of the Beehive star cluster (M-44) tonight.
8th	First Quarter Moon comes at 10:39 p.m. EDT.
11th	The Moon is at apogee this afternoon: 251,555 miles.
12th	For the next few mornings, Mercury will be rising higher day-by-day in the predawn sky toward Mars.
14th	Mercury is at greatest western elongation.
16th	Tonight and in the early morning hours of the 17th, the Moon will pass partially through the Earth's shadow (see Gazer's Gazette).
17th	Full Moon happens at 12:39 a.m. EDT.
23rd	Venus lies near the star Regulus (in Leo) tonight.
24th	Last Quarter Moon will be at 5:40 a.m. EDT.
27th	Moon is at perigee this morning: 228,208 miles.
28th	Jupiter is at aphelion. Around now, two meteor showers, the Delta Aquarid and the Capricornid, will be rising to peak strength. Look in the regions of Aquarius and Capricornus in the hours from midnight until dawn.
30th	An eclipse of the Sun will be visible from Asia (see Gazer's Gazette). New Moon at 11:52 p.m. EDT. Jupiter passes south of Saturn.
31st	Mercury passes through perihelion.



Frequently seen in the spring and fall, sunpillars occur when rays of sunlight reflect from the tops and bottoms of flat-lying crystals of ice suspended in the air. On occasion, you'll see the effect at night over streetlights, yardlights, and even car headlights. Photograph by Dan Ostergaard.

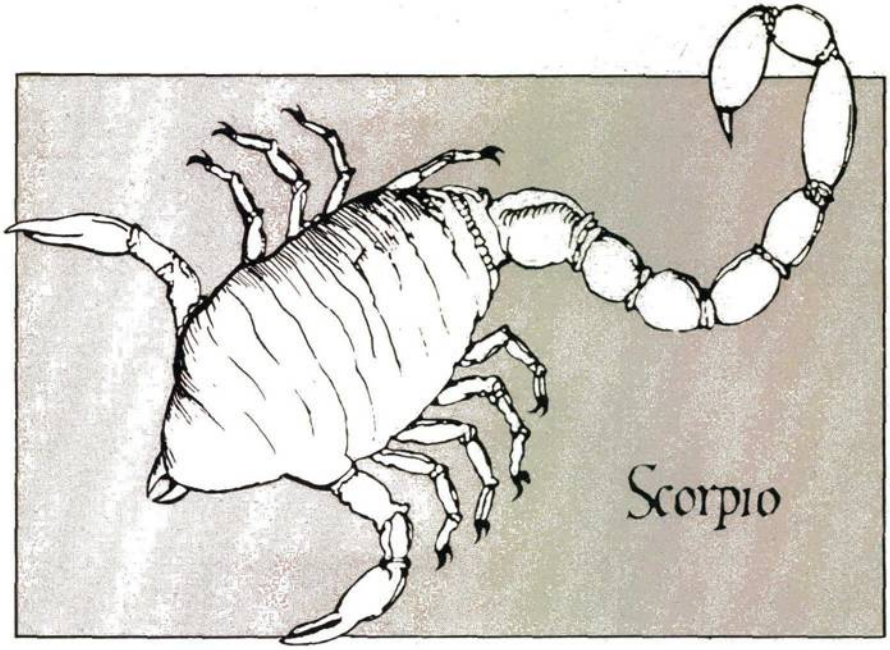
much of the time (now, for instance), the star is actually somewhat brighter than Mars. Among reddish stars in the sky, only the winter star Betelgeuse is brighter — usually — but both these red giant stars vary in brightness. Major changes in the magnitude of Antares are less common and less extreme than those of Betelgeuse, but the Scorpion's heart has at least once in modern times dimmed to only 1.8 — almost a full magnitude from its typical brightness.

The head of Scorpius is formed by a prominent line of stars, but as we now picture it, the creature has no claws. Scorpius was equipped with massive pincers in ancient times, but these were appropriated to form another constellation of the Zodiac — Libra (the scales).

Faint **Libra**, located just to the west of the Scorpion's head, contains several stars with proper names which testify to their former role in the complete Scorpion. The names of **Alpha** (α) and **Beta** (β) **Librae** are, respectively, *Zubenelgenubi* and *Zubeneshamali* — difficult indeed for speakers of English, but in Arabic they signify the southern claw and the northern claw.

We can trace the form of today's Scorpion left from Antares down to his most southern point and back up to the bright tail and stinger. Just to the east of the stinger are two beautiful naked-eye star clusters known since ancient times, **M-6** and **M-7**. Both are prominent in dark skies, but only the 3.2 magnitude M-7 (the more southern of the two) can be spotted with the unaided eye from urban and suburban sites. M-7 is a full degree wide.

These clusters are within the boundaries of the great celestial band of the Milky Way, so prominent on summer nights. A little farther east we find ourselves immersed in the widest and brightest overall section of the Milky Way visible from northern



latitudes — the region of **Sagittarius** (the archer). The brightest stars of this constellation form an asterism called the **Teapot**, whose spout seems to puff a steam of nebulae and star clouds.

The stars of spring are all departing into the west, but northern **Arcturus** is still high in **Bootes** the herdsman, followed by the half-circle of **Corona Borealis** (the northern crown). The diamond-shaped head of **Draco** the dragon together with **Hercules** to the south now occupy the zenith for viewers at temperate latitudes. Last month, we located the great globular cluster in Hercules, **M-13**, and noted that it was a naked-eye glow in reasonably dark skies. If you get a chance to observe in extremely good conditions, there is yet another fine globular near the four-sided Keystone part of Hercules — **M-92**, with a total integrated magnitude of 6.1.

Hercules is inverted for viewers at mid-northern latitudes, and his head is marked by his most southern prominent star, **Rasalgethi**. This giant sun is a beautiful double in telescopes, but, as an unusual variable, it's also interesting to the naked eye. Rasalgethi fluctuates quite irregularly somewhere between extremes of magnitude 3.1 and 3.9 with a period which averages only about 90 days. This is an excellent star to study — try rating it for yourself.

Close to Rasalgethi ("the head of the kneeling one") is Rasalhague ("the head of the snake-man") — the snake-man is **Ophiuchus**. The loose, mostly faint pattern of Ophiuchus can be extended east and west by the two lines of the divided constellation **Serpens** — to the west is Serpens Caput (the serpent's head) and to the east is Serpens Cauda (the serpent's tail).

The **Milky Way** now arches grandly from southern Sagittarius all the way to the northeast, with the great **Summer Triangle** glittering in the midst of the celestial stream. High in the east, is the brilliant blue Vega, attached to a little diamond of stars to form Lyra the lyre. Lower though farther north is white **Deneb**, the tail-star of splendid **Cygnus** the swan, seemingly flying south down the stream of the Milky Way. And still rising in the southeast is **Altair**, the bright star marking the head of **Aquila** the eagle. The Summer Triangle is at its best very late in the summer, so these three great stars with their constellations will be in prime position for evening viewing over the next few months.

skylore

The scorpion represented by stars in the southern summer sky was a menacing figure in the tales of many cultures, particularly those of ancient Greece. According to some accounts, this monster was the slayer of Orion, who now keeps the greatest possible distance between himself and the poisonous beast.

In the Greek story of Phaethon, the rash youth who tried to drive the Sun-chariot across the sky, it is sometimes said that Scorpius frightened the horses of the Sun, and Phaethon was not able to calm them. North Africa was turned into a desert when the wildly careening Sun-chariot came too close, while northern Europe froze. Zeus saw that the whole world was in danger and struck Phaethon dead with a thunderbolt — a weapon which never failed.

Plutarch tells us that in Egyptian mythology, Horus, the son of Osiris and Isis, was killed by a scorpion sent by the god Set. Horus was brought back to life by Ra, the Sun god, and eventually avenged the killing of Osiris. Horus was sometimes seen in the stars of our constellation Orion; and Robert Graves identifies this tale of Osiris and the scorpion with the Greek one of Orion and Scorpius. Graves also notes that the great Babylonian hero Gilgamesh was attacked by scorpion-men — again identified as Scorpius.

When it included Libra the Scales as its monstrous claws, the constellation Scorpius was far larger. The unabridged Scorpius was known as the Great Sign (in the Zodiac) and it was not until late classical times that the long-known Libra became the official and commonly accepted configuration of stars in this area.

Although Scorpius was "disarmed" in a literal sense, he still retained his sting, formed by a brilliant and prominent curl of stars. This pattern has in many cultures been a constellation of its own. The stars of Scorpius have been parts of several different figures in the long history of China, but in the time of Confucius (around 500 B.C.), the forepart of our present constellation was *Ta Who*, the Great Fire (an ancient name for the star Antares), and the stars of the tail formed *Shing Kung*, the Divine Temple.

It was in the farthest East, however, that the stars of the tail were regarded with probably the greatest interest. It is little wonder that the people of Polynesia should find this asterism notable, because it passes high overhead in their skies.

In the rich star-legends of Polynesia, the stars from Mu^1 (μ^1) and Mu^2 (μ^2) to Lambda (λ) and Upsilon (υ) Scorpii (our scorpion's tail) were the Fish-hook of Maui. It is said that the god Maui was fishing with this instrument when he drew forth from the ocean the island of Tongareva, or New Zealand, and named it *Te-ika-a-maui*, Fish of Maui. When Maui discovered the fish was covered with grass, trees, animals, and people he hurled his fish-hook up into the sky with joy.

The Hervey Islanders had another story about the two star-pairs on the two ends of the hook. Mu^1 and Mu^2 are 3.1 and 3.6 in magnitude, respectively, and less than 6′ of arc apart, so this is a fine close pair for the naked eye. Lambda and Upsilon (Shaula and Lesath) are 1.6 and 2.7 and a full 35′ apart — can you believe that the Moon could fit between these two? In the Hervey Island myth, Mu^1 is a little girl called *Piri-ere-ua*, "the Inseparable," who, with her smaller brother (Mu^2), ran away from home because of ill treatment by their parents. The parents came to the sky themselves, as Lambda and Upsilon, and are forever pursuing the children. The two "children" actually are physically connected stars, but according to *Burnham's Celestial Handbook*, their 346″ separation in the sky may be almost a full light-year in space.

ASTRONOMY IN FOCUS

SMM Still Alive

Sir / The SMM spacecraft has not "died" as stated near the end of "The Solar Maximum Mission," ASTRONOMY, May 1981. Three of the original eight instruments are still operating and continue to return valuable data on the Sun. As recently as April 24, 1981 the Gamma Ray Spectrometer (GRE) and HXRBS recorded data from the largest solar flares which have occurred in this cycle. The SMM satellite's pointing capabilities may be impaired — but it is far from dead.

Edward L. Chupp
Professor of Physics
Principal Investigator
SMM Gamma Ray Spectroscopy
Experiment (GRE)

Cosmos Hush Puppies?

Sir / I grew up in the age of the Apollo missions and *Star Trek*, so naturally I fell in love with the stars and the dream of space travel some time ago. Back in 1976, my interest in astronomy grew stronger, so I purchased my first telescope and became an amateur astronomer. Since then, I've found that reality can be more fun than science fiction — and I must say that your magazine has helped me to enjoy astronomy even more.

Although I thoroughly enjoyed *Cosmos* with its sometimes dazzling special effects, at the same time I couldn't help but wish that everyone could experience the first-hand joy amateur astronomers undergo when, after searching for a particular object, they suddenly "discover" it. Even if the celestial objects seen in a telescope do not display the beautiful colors often seen in astrophotography, the image in the eyepiece is real.

You feel special when you realize that the globular cluster or nebula — whatever you're viewing — is very far away and not everyone has had the opportunity to see it. And there are so many things to see in the universe — so many! I think *Cosmos* will make more people aware of that and will probably increase the number of amateur astronomers.

As for Dr. Sagan, I don't always agree with everything he says, but I think he is an excellent teacher and writer. And when Cosmos comes on the re-runs, I'll pay more attention to his feet. I thought he was wearing a pair of Hush Puppies!

Debra J. Williams
Omaha, NB

Cosmos Turn-On

Sir / The reviews of *Cosmos* by Scriba and the Moods, though widely divergent, missed the boat in evaluating the effectiveness of the series.

The stated intent of *Cosmos* was not to provide hard facts for scientifically oriented viewers, nor to personify Carl Sagan — it was to ignite the flame of inquiry in the fresh minds of viewers. That is, to the joys and "DO"-loops of the scientific thought processes.

To praise the image of Carl Sagan means the medium was more important than the message. To condemn imagery for the lack of hard facts means to ignore the selling power of emotions.

The success of *Cosmos* can only be measured by how many viewers were turned on to the science of quest and experimentation.

Frank Gurney
Arlington Heights, IL

Frustration with Cosmos

Sir / On reading the Jay Scriba review of Cosmos in the April issue, I recalled the frustration I experienced while watching as much of the series as I could bear. I was expecting science — but I got a guided tour through the expansive ego of Carl Sagan. I enjoyed the spectacular visual effects, but there was a glaring paucity of information — only endless gushings of Sagan's pseudo-poetry. Besides, the visual effects were interrupted over and over again by the superimposed image of Sagan's smiling face.

Scriba's review at least gives an indication of why the show was so successful — though, by the middle of the second program I could no longer force myself to watch : it seems the reviewer's wife thinks Sagan is sexy. So much for science. Invariably, anyone I talked to who knew anything about astronomy hated this series, and anyone devoid of any sort of scientific curiosity loved it.

True, there were good moments. But I couldn't suffer through sixty minutes of Sagan the sociologist, historian, poet, philosopher, guru, and media-star ad nauseum, in order to see five good minutes of astronomy.

Perhaps Sagan can amass an army of lemmings with this pompous series. But there is no place for *Cosmos* in a magazine like ASTRONOMY. If I read more about Sagan or *Cosmos* in future issues, I'll request cancellation of my subscription. Then I can not read your magazine and not watch *Charlie's Angels* at the same time.

Kenneth Kalish
Pringle, PA

Average Message

Sir / I wonder if S. and J. Mood missed the point in their review of *Cosmos* in the April issue? I live in an average suburb of an average city, and work at an average job;

and I'd like to tell S. and J. that the average person has not looked at the cosmos before.

Cosmos is the first brush with science most people have had since sitting in a high school class with their minds on acne, the sock-hop, and that cute new kid across the aisle. I have seen people amazed to discover Leo, Aries, and Libra are actually constellations that may be seen in the sky some starry nights, not just "signs" in the astrology columns of the newspapers.

I may be mistaken, but I assumed it was these people Carl Sagan wanted to reach with *Cosmos* — those lost in today's pseudo-scientific fog — to show them that there are real wonders. What possible difference can it make if Dr. Sagan's "Spaceship of the Imagination" looks like thistledown? Mine might look like the *Millennium Falcon*, or Freddie's like the *Enterprise*. The important thing is we have them. Do they?

The message I see in *Cosmos* is that we have no need for the supernatural: the natural is super enough! And that is a message much needed by the average people of today.

J.M. Cope
Dublin, CA

Nothing Wrong with the Basics

Sir / After reading "A Revolution in Amateur Astronomy" in your March 1981 Forum, I was very depressed. I chose astronomy as a hobby because it seemed like a simple activity in which I could do work of real value with a minimum of equipment. Now the "Equipment Revolution" is upon us, and the simple pleasure of amateur astronomy seems to be going down a black hole of massive instrumentation. Have we forgotten naked-eye viewing? Can observations using binoculars make any real contribution to astronomy?

Please restore my faith in the simple pleasures of astronomy.

R. J. Morris
Rossville,GA

Mr. Morris / The equipment revolution has taken nothing away from the pleasures of using small telescopes, binoculars, or your own eyes — it has only expanded the limits of "amateur" astronomy.

While Dobsonian telescopes are big, they're simple and they make large apertures available — instead of unattainable. Rather than pay $1,600 for a telescope, you can build one yourself for a few hundred dollars —the cost of a small refractor.

Improved films mean better pictures for the same effort. Electronic detectors will eventually mean fainter stars for small instruments. Meanwhile, with binoculars or a small telescope, you can contribute valuable variable star estimates to the AAVSO, search for novae or comets, or time lunar occultations — and of course the pleasure of introducing children and adults alike to the stars and constellations requires no equipment at all.

Ooops

Some mistakes slipped by us in the June issue: On page 16, the spectrum at top is that of an H II region in NGC-2903 and shows uncontaminated old gas. That below is from M-101 and shows the increased enrichment in a young H II region. On page 52, the B = 160 and B = 80 photos were transposed. On page 54, the photo of M-83 was taken with an 8" f/10 telescope and enlarged in printing.

behind the scenes

a commitment to space

You have probably spent hundreds of dollars on "space" and astronomy. You've likely bought books, magazines, posters, color slides and star atlases. You may be planning to buy, or have already bought one or more telescopes, plus eyepieces, accessories — a considerable investment. For entertainment, perhaps you saw *2001*, *Star Wars*, *Close Encounters*, *The Empire Strikes Back* . . . maybe even several times.

You've done these things, if you're like me, to stimulate your mind, to free your imagination, and to know what's out there. Yet today we live in a country where space exploration — despite the recent widely applauded flight of *Columbia* — is dying. With major missions to Venus and Jupiter postponed until 1988 or later, and with no prospect in sight of returning to the Moon or exploring Mars, our country is clearly retreating from space.

When Van Kane told me he was forming a group to preserve a U.S. mission to Comet Halley — and then asked me to be on the Halley Fund Advisory Council — I must admit I was rather cautious. I realized that I would commit not only myself, but also ASTRONOMY to asking you, ASTRONOMY's readers, to support the fund. Please consider carefully what is important to you, and if space exploration is high on that list, contribute what you can. (Van Kane has written an appeal to you which appears in this month's Forum; see page 24.)

For citizens to raise money to support a government agency is virtually unheard of. Yet it's happened. This makes contributions to the Halley fund almost impossible for the officials of our representative government to ignore. We can push our leaders toward the future in space — and into supporting the exploration of the solar system — if we show them we mean what we say.

Nothing but hard cash can show our support with so much force. When we say "Here's my money. I want America to send a mission to explore Comet Halley," they have to listen.

Your contribution to the Halley Fund shows that you are committed to an ongoing program of space exploration. Comet Halley is just the first step — a vital first step — because we won't get another chance at this comet for 76 years.

The Halley Fund is a spin-off of the Viking Fund, a highly effective effort to support the ongoing data collection from the remaining Viking Lander. Last year, Viking Fund Director Stan Kent presented $60,000 to NASA — enough to support data reception for two months. There is already $25,000 in the kitty for next year's contribution.

You've already spent money on space. This time, why not make it really count? Even if you've never given to a cause before, if you believe in the promise of space, give to this one.

Sincerely,

Richard Berry

Richard Berry
Editor

equipment atlas

the electronic sky

by
Ben Mayer

The search for electronic methods to enhance human vision was inspired by the military's desire for a device that would permit seeing in the dark. Their quest was successful — and today this technology allows pilots to land on unlit runways, helps ship captains navigate unmarked channels, and enables soldiers to pinpoint moving targets — all in the black of night.

Only recently was this "sword" forged into a "ploughshare." And while professional astronomers have had access to so-called "image intensification devices" for about a decade, these remarkable systems are just now beginning to reach the hands of amateurs.

"If you are working in the dark, an image intensifier can help you see the light" is the slogan used by one manufacturer of one of the devices that may turn out to be the most important advances in amateur astronomy in the next few decades. If "aperture" was the name of the game in the sixties and seventies, "gain" could become the rallying cry of the eighties and nineties.

Although the cost of image tubes may now lie beyond the reach of the casual stargazer, increased demand from industry for this almost magical equipment which turns "darkness into light," could drive prices substantially downward. We have seen this in in the computer field, and wherever electronic components have become mass produced.

Such reductions in price are bound to have heavy impact — spawning a new generation of telescope makers and users who will not only speak of Newtonians, catadioptrics, and Erfles, but whose shop talk will also include *operating voltage, cathode sensitivity* and *equivalent background input*.

As the name implies, image intensifiers boost the faint light from a distant star, galaxy, or terrestrial scene so dimly seen forms emerge much brighter — to be seen as a spiral galaxy, a cluster of stars, a tree, a building, or even an armored personnel carrier. When the device is attached to a telescope and trained upon an actual source of faint stellar light, we note dramatic breakthroughs in seeing. It is as if the aperture of the instrument has been magically increased.

An image intensifier is to light what an amplifier is to sound: a small signal goes in and a large signal comes out. Most intensifier systems consist of several standard amplifying modules — each stage increasing the light by 20 to 100 times. By using two or more in sequence, *high-gain multi-stage tubes* can be created. The second stage intensifies the output of the first, while the third stage further multiplies the combined product of the first and second stages for a total amplification of 20,000 times or more.

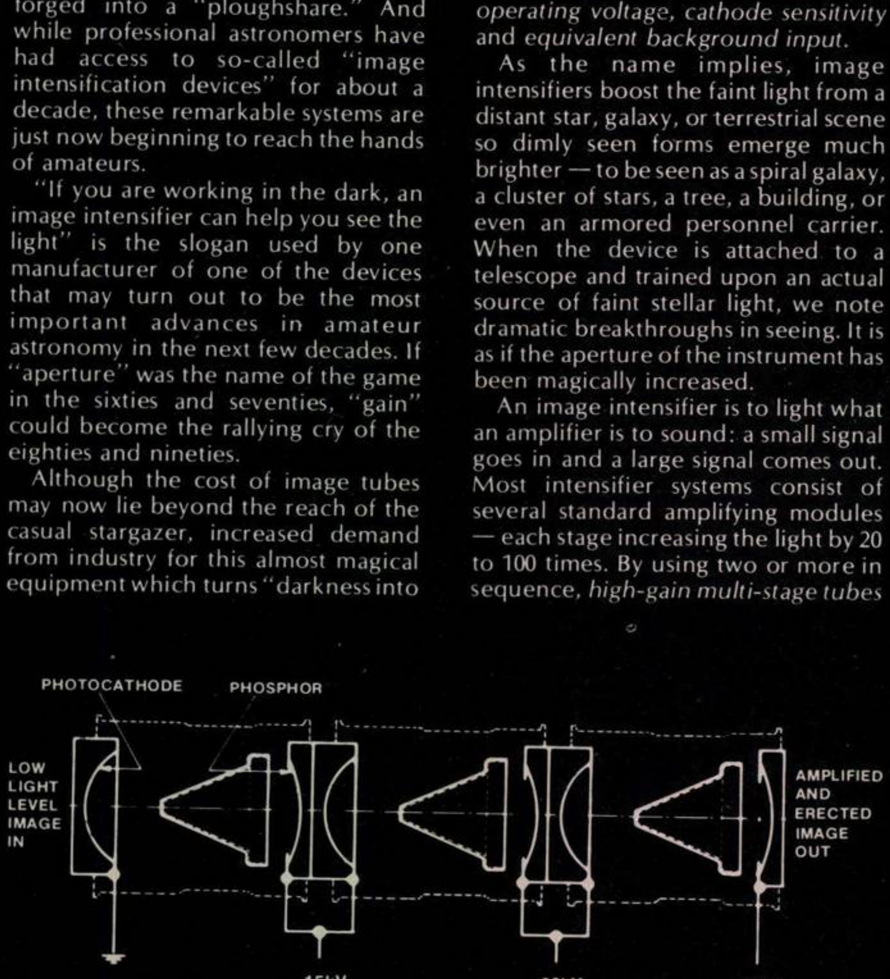
Both the front end, where light from your telescope or lens is focused, and the output back end appear to be opaque glassy faceplates when viewed under normal light (with the intensifier's power switch in the *off* position). The faceplates are composed of large bundles of glass fiber optic strands. The inside of the input end faceplate is curved and chemically coated to release electrons where light strikes. The electrons, in turn, are accelerated by high voltage differences and focused onto a phosphor screen (like a TV screen) where they generate light, producing an intensified image of the one from the focal plane of a lens or telescope.

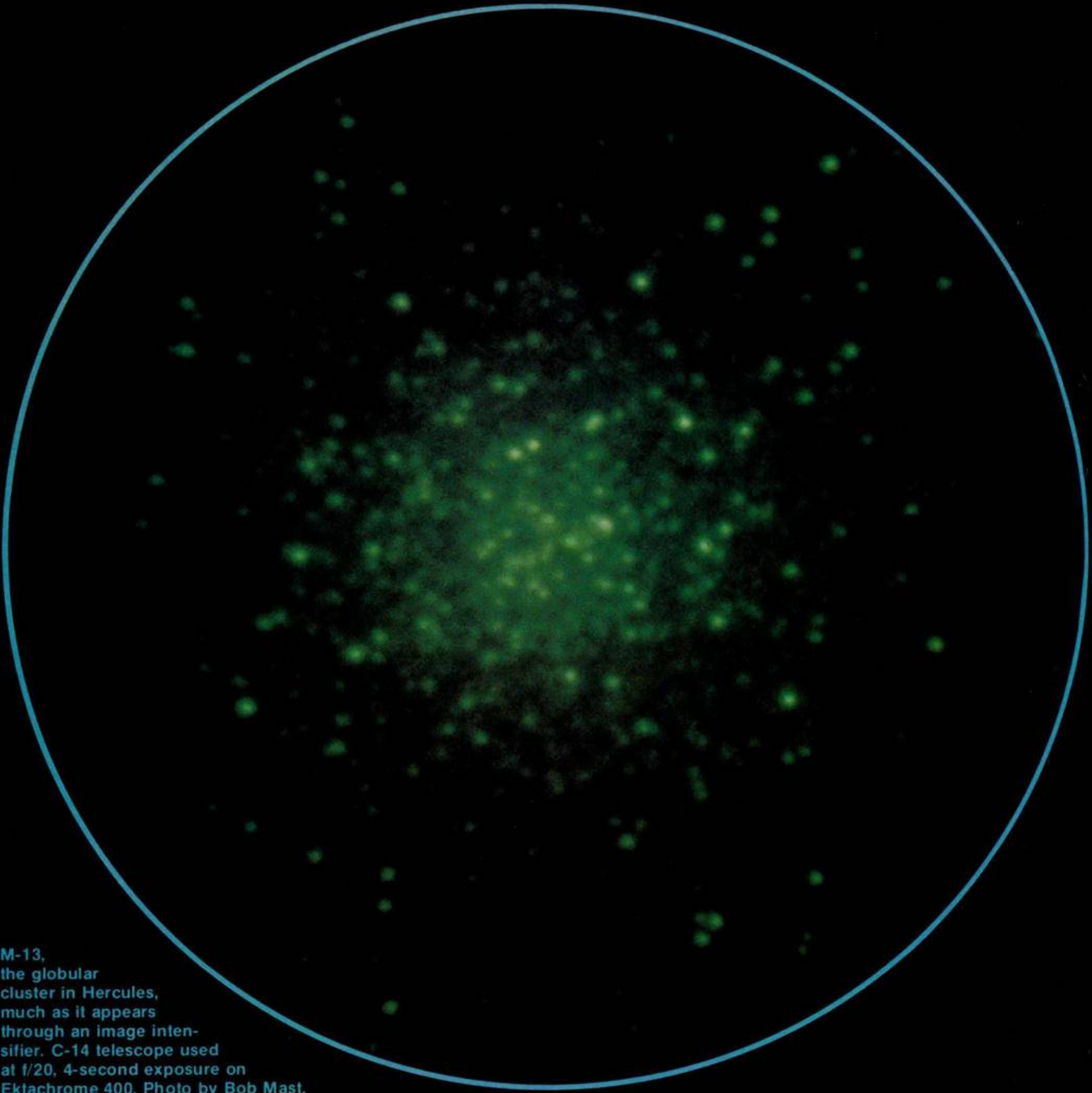
This process requires extremely high voltages. In modern intensifiers, these are generated inside the image tube package (without hazard to the user) from penlight batteries.

For amateur astronomical use, the image tubes fit into cylindrical metal packages with their high-voltage electronics and batteries — yet the assembly weighs only two or three pounds. The input is equipped with standard adapters for telephoto lenses or telescopes, and the output end for eyepieces, film cameras, or video cameras.

You must be careful when you turn on an image intensifier: too much light can hurt them. For maximum safety, use an intensifier only under conditions of darkness. High light levels — even viewing a bright star through a telescope — may cause permanent damage to the phosphor on the anode.

When you turn on a tube — even in total darkness — the output screen lights up with a phosphorescent green





M-13, the globular cluster in Hercules, much as it appears through an image intensifier. C-14 telescope used at f/20, 4-second exposure on Ektachrome 400. Photo by Bob Mast.

color reminiscent of oscilloscope screens. Look carefully through the eyepiece, and you'll see the inherent "background noise," brief scintillations distributed evenly over the entire screen, or slightly concentrated toward the center. Momentary pinpoint flashes will appear sporadically. These are cosmic rays striking the cathode.

Demonstrations of night seeing devices using just a telephoto lens at the input never fail to elicit astonishment from new users. You can see the entire night scene, appearing as it did just after sunset, except in the even, shadowless, greenish glow of the phosphor.

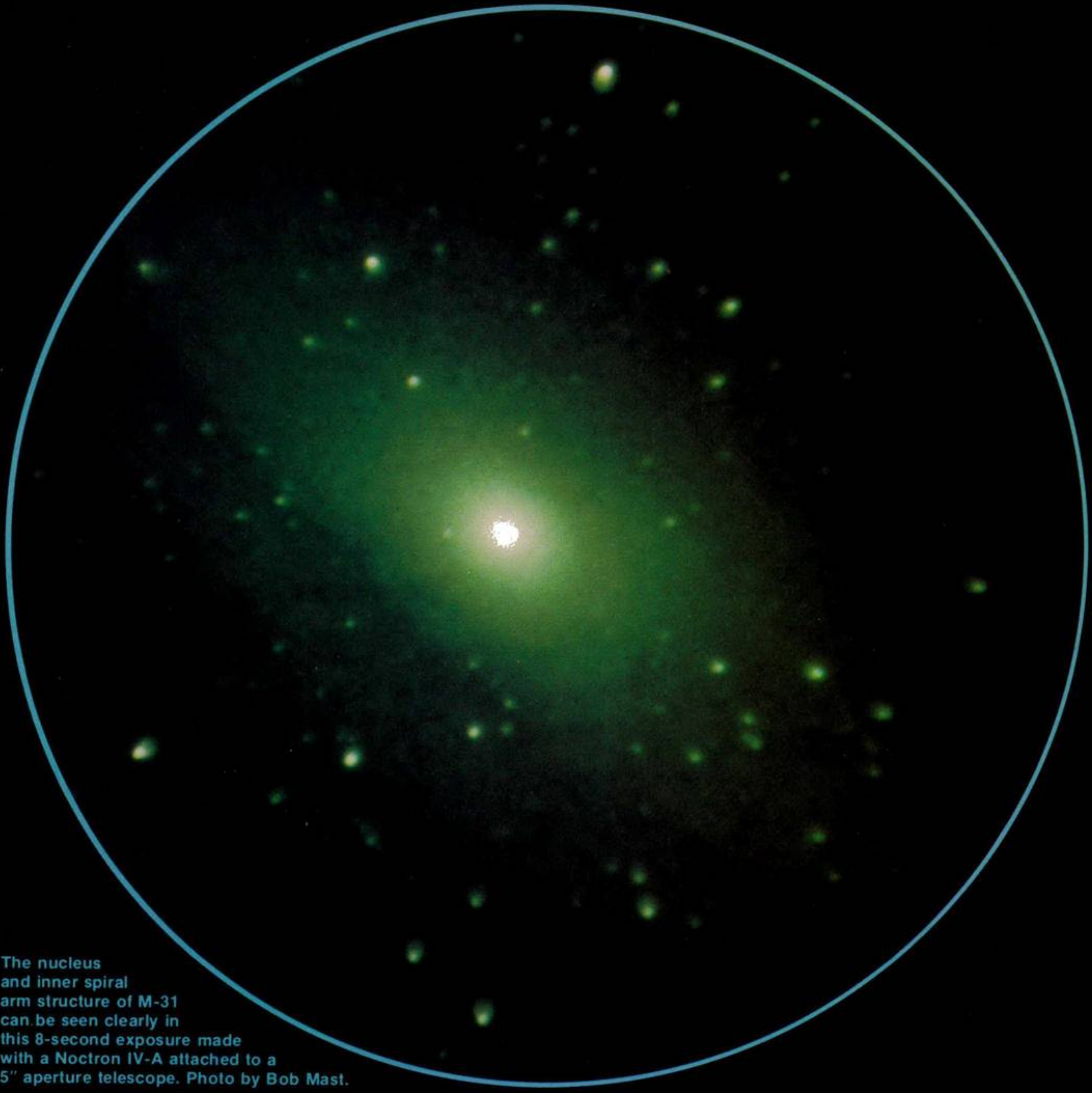
Point the image intensifier at the night sky, and you'll see stars to ninth or tenth magnitude. Brighter stars leave trailing after-images on the phosphor as the handheld assembly is moved from one target to the next.

Glowing cigarettes create bright hotspots, and the occasional red-masked flashlight appears dazzlingly brilliant. Carelessly used flashlights and automobile headlights constitute a real hazard to an image intensifier.

Attached to an 8-inch reflector, the remarkable potential of the device becomes fully evident. When you allow light from the telescope into the intensifier, you'll see a field of stars glowing on the phosphor in green light. The whole image will have a scintillating quality, but the flickers appear smaller than any visible star and do not detract from the tube's effectiveness. In photography, the momentary flashes average out, and only rarely leave spurious marks on the emulsions.

You can see stars one to two magnitudes fainter than you can without intensification, and instead of straining to see them, you spot them easily against the green glow of the night sky. You quickly find skyglow — not faintness — limits what the image-tube-aided observer sees.

Globular clusters, with their thousands of discrete stellar light sources, are particularly enhanced by image tubes. You'll see component stars to approximately 13th or 14th magnitude, and unlike photographic images — in which the centers of clusters appear burned in — the



The nucleus and inner spiral arm structure of M-31 can be seen clearly in this 8-second exposure made with a Noctron IV-A attached to a 5" aperture telescope. Photo by Bob Mast.

reading produced by an intensifier provides an almost three-dimensional perspective. Countless stars appear, superimposed layer on layer on top of each other.

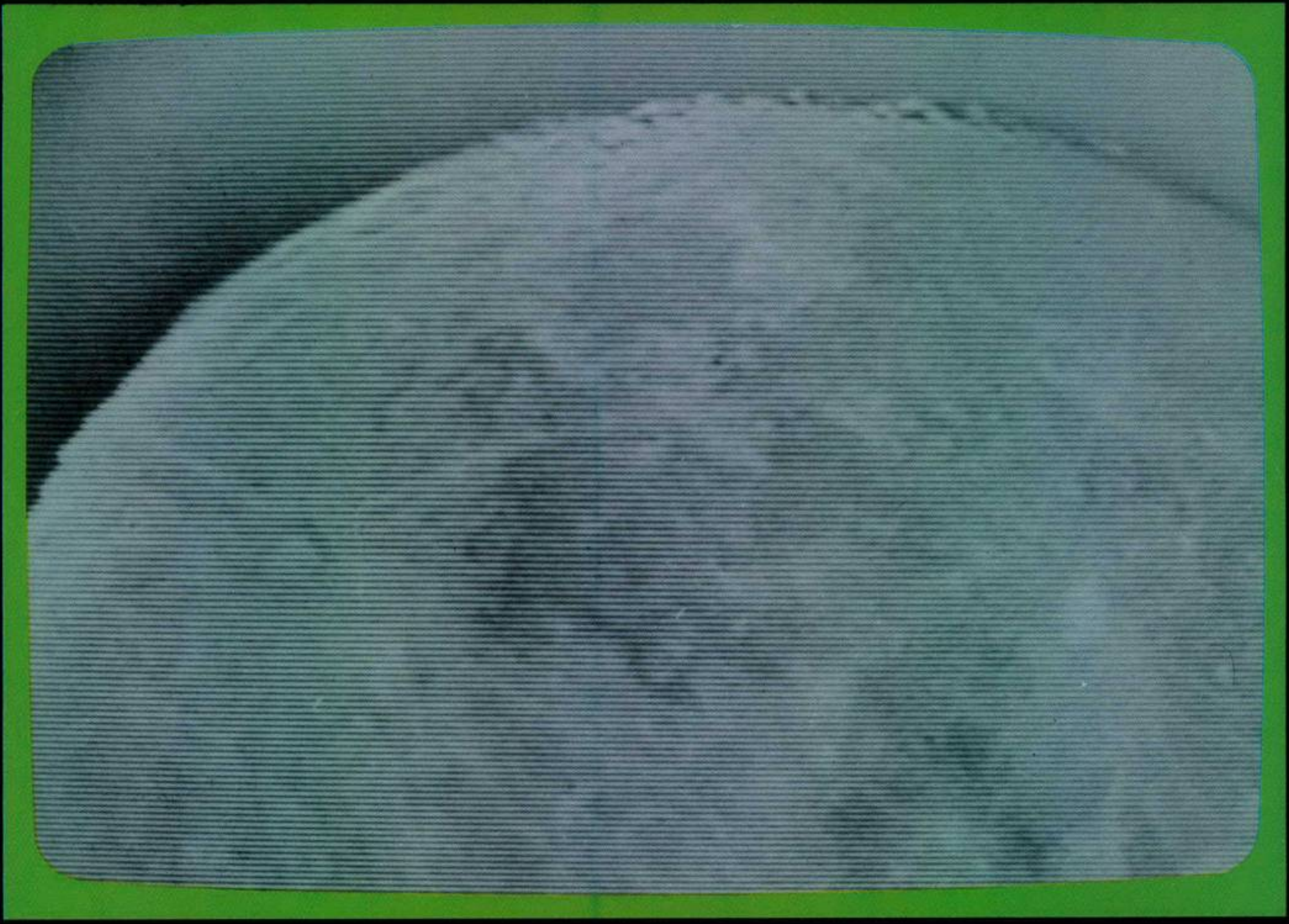
There is one group of objects where direct telescopic viewing does not offer the benefits you might expect of image intensification. They are the extended diffuse nebulae and spiral galaxies. Except for their central cores, outlying regions tend to appear indistinct, and structure beyond what the eye can see is apparent in only the brightest galaxies. Even image intensifiers are ultimately limited by the background light of the night sky.

The greatest potential for electronic image intensifiers lies in astrophotography. Almost unlimited new possibilities exist — especially for black and white work — since the yellowish-green output does not lend itself well to color photography.

If the output faceplate of many intensifiers were not curved or recessed, it would be possible to bring the film into contact with the fiber optic back and obtain a very efficient transfer of light to the film. Professional astronomers, in fact, use special fiber optic adapter plugs and employ this approach. The image can be recorded, although with some light loss, if you use a "transfer lens" — a special camera lens made for close copying — between the output phosphor and film. These fast (f/1.4) specialty lenses permit sharp focusing onto the output plate, but they tend to distort and elongate star images around the edge of the field. This can be corrected by stopping down to f/2, f/2.8, or even f/4, though some loss of light will occur. Normally, you'd use a standard 35mm camera body with the image tube and transfer lens.

With an image intensifier-equipped camera on a 14-inch telescope, it is possible to photograph globular clusters, for example, in great detail, with only a two minute exposure and an f/2 transfer lens. A crisp frame-filling image of the Whirlpool Galaxy can be captured in four minutes at f/4. It's possible to record 17th and even 18th magnitude stars in just a few minutes.

Astrophotography with smaller telescopes — combined with these



Conventional television works well on bright objects such as the Moon and planets. Low-light TV systems can reach a few bright deep-sky objects, but special equipment is required for deep-sky observation. Photo by Richard Berry from the TV system mounted on a 12" reflector at Stamford Observatory.

extraordinarily short exposure times — can be a boon to the tired astrophotographer. Long, tedious guiding sessions could become a thing of the past.

The Video Connection

Attaching a night surveillance television camera to the output plate of an image intensifier seems the next logical step in the "electronification" of astronomy.

But how much better can a system like this help you see? With a 14-inch telescope, you see stars to about 12th magnitude, and a few stars in the brightest globular clusters. Also, the Moon offers an impressive target. If your telescope has electric motors, you can have dramatic "live" excursions over the craters near the terminator.

The Price: $3,500+

As yet, only a few image intensifiers are offered in the marketplace. Data concerning their actual brightness gains are couched in hard-to-understand terms. The Noctron-IV, on which much of the information in this article is based, claims an image tube amplification of 60,000 through its three stages. In lay terms, it can reliably produce a brightness increase by a factor of about $3,500! At that price, it is a useful instrument in that it vastly expands the light-gathering power of small telescopes

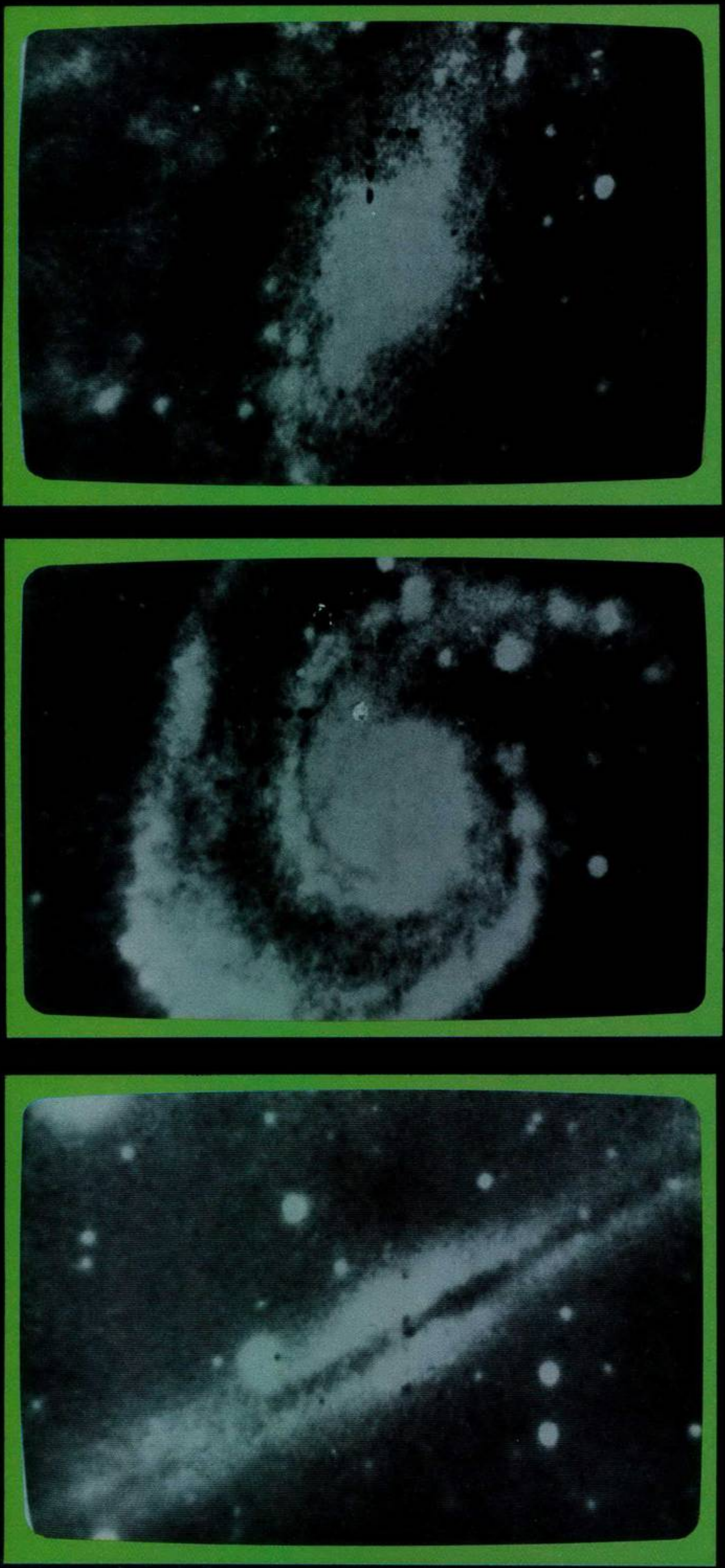
As you can see, without special modifications, TV cameras operating at the standard scanning rate of 30 frames per second are not sensitive enough. Professional astronomers use television on their telescopes, but they slow their cameras' scan rate to once per second or even slower and thus achieve a much greater sensitivity. They also use special equipment to display a flicker-free image on a TV screen. Even if the sensitivity of the image tube were unlimited, the limitations of available (and relatively affordable) low light level television (L^3TV) systems would soon curtail such endeavors.

In theory, a TV camera might be good for off-axis remote video guiding of, for example, color deep-sky cold camera exposures. However, it's very difficult in practice: for in addition to all the many necessary pre- and post-exposure steps which must be taken for chilled emulsion color photography, finding a suitable guide star, focusing, and transmitting it through the labyrinth of prism, barlow, fiberoptics, cathodes, anodes, transfer lens, and coaxial cable into the center of a small video monitor, is no small task. Setting up can easily take up as much time as some exposures — and all the preparation has to be done in the cold you meant to escape.

Another important consideration that is easily overlooked concerns dark adaptation of the user. One bright light flash on the video monitor, and the faint telescopic guide star, visually acquired, becomes irretrievable. Not only does remote off-axis video guiding add complexity to astrophotography, but it also burdens the telescope with extra weight, and limits the method to use with heavier instruments.

Image Processing at Home

Justifying the purchase of both an image intensifier and an L^3TV system is difficult. But when the image intensifier is used for astrophoto-



Television offers a chance to display — even enhance — astrophotos so that all the detail in a negative can be seen. Top to bottom: NGC-5236, NGC-5194, and NGC-791; each a 4-minute exposure on Tri-X with a Noctron-IV intensifier and a 14-inch telescope. Photos by Ben Mayer.

graphy and the resulting films are then enhanced via the TV, the possibilities are extraordinary. Almost as if to compensate for the inadequacies of the TV system on the real sky, inspection of film negatives through a video system reveals elusive sky objects at their very best. Adjustment settings for "brightness" and "contrast" afford a degree of instant picture control which could only be duplicated in a photo darkroom with hours of experimentation. For example, the filamentary structure of spirals can be enhanced at will.

Using various copy lens combinations, you can control the image size as easily as you can in slide copying. It is possible to video-view an entire 35mm negative at a time, or to zoom in and scrutinize a tiny portion of a negative — until film grain limits further enlargement.

Behold the Future

At this point, you have perhaps instinctively realized that many of the resources of professional astronomers have fallen into your hands. Perhaps within the next decade, these will become more common, and many observers will begin to experience the thrill of combining the limitless challenges of observation, astrophotography and "data reduction." Reduction — the study and exploitation of that which has been observed or photographed — often takes many times longer and involves much more effort than actual observing or photographing.

At last, the cloudy evenings and rainy Sundays can be put to productive astronomical use. Suddenly — through a combination of elements involving not only a fascination with the stars, but access to old knowledge and new equipment — you can make important contributions to science. You might effortlessly and quickly photograph a dozen galaxies in one observing session and "blink" them for supernovae. The sky is truly the limit. The most valuable investment you can make in stars is not one which involves the acquisition of costly equipment, but the investment of your own time to its use.

Ben Mayer is a well-known Los Angeles amateur astronomer who has experimented with intensifiers and L³ TV. He recently spoke on this subject at Astrophoto-IV. His motto: "Let there be **more** *light."*

The birth and death of a star...galactic discoveries... colonies in space...black holes and the universe...

Sooner or later, all of the secrets of the heavens are revealed in the only book club of its kind, the

Astronomy Book Club

amateur astronomer's handbook
Fourth Edition by J.B. Sidgwick
Completely revised by James Muirden
THE RADIANT UNIVERSE
ELECTRONIC IMAGES FROM SPACE
Michael Marten · John Chesterman
MONSTERS IN THE SKY
PAOLO MAFFEI
DICTIONARY OF ASTRONOMY, SPACE AND ATMOSPHERIC PHENOMENA
DAVID F. TVER
STARS
Their Birth, Life, and Death
Josif S. Shklovskii
NEW CONCISE ATLAS OF THE UNIVERSE
Patrick Moore
BURNHAM'S CELESTIAL HANDBOOK
3 VOLUMES

36396. BLACK HOLES, QUASARS, AND THE UNIVERSE: The Frontiers of Astronomy. *Henry L. Shipman.* **$16.95**

42355. DISEASES FROM SPACE. *Hoyle and Wickramasinghe.* Have extraterrestrial viruses and bacteria been responsible for plagues? **$11.95**

40675. COSMIC LANDSCAPE. *Michael Rowan-Robinson.* Explains the wave-length bands of the universe: light, radio, X-ray, and more. **$12.95**

42208. DICTIONARY OF ASTRONOMY, SPACE, AND ATMOSPHERIC PHENOMENA. *David F. Tver et al.* Over 2,000 entries. Includes star charts and more than 150 illustrations. **$19.95**

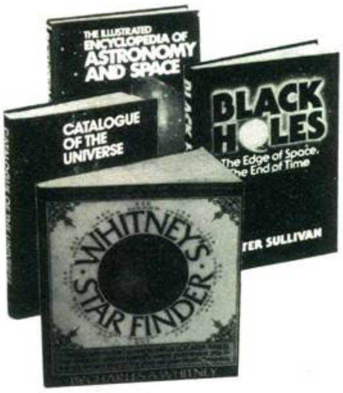
34663. ASTRONOMY: The Cosmic Journey. *William K. Hartmann.* Over 600 photographs. **$17.95**

80250. STARS: Their Birth, Life, and Death. *Josif S. Shklovskii.* **$17.50**

55001. ILLUSTRATED ENCYCLOPEDIA OF ASTRONOMY AND SPACE. *2nd Ed.* **$17.95**

36978-3. BURNHAM'S CELESTIAL HANDBOOK: An Observer's Guide to the Universe Beyond the Solar System. *Robert Burnham, Jr.* 3 volumes. Over 2000 pages. *Counts as 3 of your 3 books.* **$60.00**

Basic Astronomy Library


THE ILLUSTRATED ENCYCLOPEDIA OF ASTRONOMY AND SPACE
BLACK HOLES
The Edge of Space, the End of Time
WALTER SULLIVAN
CATALOGUE OF THE UNIVERSE
WHITNEY'S STAR FINDER

Here's a carefully selected set of four books that will provide you with a basic, well-rounded astronomy library. First, a "must" for any astronomy reader, the **Illustrated Encyclopedia of Astronomy and Space.** Next, a marvelously readable overview of the latest advances in the "new astronomy," Walter Sullivan's **Black Holes.** Then, the **Catalog of the Universe,** which features more than 300 photographs. Finally, a useful guide that will show you how to locate and identify more than 4,000 stars that are visible to the naked eye, **Whitney's Star Finder. Publishers' price for four-book set: $60.80.** To order check **Basic Astronomy Library-G** on your coupon.

Take any 3 books for only $1.00 each (values to $60.00)

You simply agree to buy 3 more books —at handsome discounts—within the next 12 months.

(Publishers' Prices shown)

87111. WHITNEY'S STAR FINDER. *Charles A. Whitney.* Field guide to the night sky. **$6.95**

63015. MONSTERS IN THE SKY. *Paolo Maffei.* Supernovae, quasars, black holes, more. **$15.00**

43057-2. EARTH AND COSMOS. *Robert S. Kandel.* Explores intricate Earth-space links in non-technical language. *Counts as 2 of your 3 books.* **$30.00**

36400. BLACK HOLES: The Edge of Space, the End of Time. *Walter Sullivan.* **$17.95**

37353. CATALOGUE OF THE UNIVERSE: A Survey of the Most Familiar and Extraordinary Objects in the Universe. *Paul Murdin et al.* More than 300 photographs. **$17.95**

57833. THE LAROUSSE GUIDE TO ASTRONOMY. *David Baker.* **$15.95**

70768-2. PROJECTS AND DEMONSTRATIONS IN ASTRONOMY. *Ronald Tattersfield.* How to plot the orbit of a comet, predict a lunar eclipse, and much more. *Counts as 2 of your 3 books.* **$27.50**

47210. THE EXPLODING UNIVERSE. *Nigel Henbest.* Spectacularly illustrated. **$19.95**

66275-2. THE ORIGIN OF THE SOLAR SYSTEM. *S.F. Dermott. Counts as 2 of your 3 books.* **$39.00**

79175. SOLAR SYSTEM. *Peter Ryan.* Outsized, well illustrated. **$19.95**

40715. THE COSMOGONY OF THE SOLAR SYSTEM. *Fred Hoyle.* **$16.95**

41759. THE DEATH OF THE SUN. *John Gribbin.* **$8.95**

Membership Benefits

In addition to getting either the BASIC ASTRONOMY LIBRARY for $3.00, or 3 books for $1.00 each when you join, you keep saving substantially on the books you buy. • Also, you will immediately become eligible to participate in our Bonus Book Plan, with savings of 70% off publishers' prices. • At 3-4 week intervals (16 times per year) you will receive the Book Club **News,** describing the coming Main Selection and Alternate Selections, together with a dated reply card. • If you want the Main Selection, do nothing and it will be sent to you automatically. • If you prefer another selection, or no book at all, simply indicate your choice on the card, and return it by the date specified. • You will have at least 10 days to decide. If, because of late mail delivery of the **News,** you should receive a book you do not want, we guarantee return postage.

69327. PLANETS AND MOONS. *William J. Kaufmann III.* **$13.00**

82735. TELESCOPES FOR SKYGAZING. *Henry E. Paul.* Classic reference. **$10.95**

84288. TIDES AND THE PULL OF THE MOON. *Francis E. Wylie.* **$12.95**

40837. CRAB NEBULA. *Simon Mitton.* **$16.95**

73282. THE RADIANT UNIVERSE: Electronic Images from Space. *Marten and Chesterman.* Over 125 photos. **$17.95**

34745. ATLAS OF THE PLANETS. *Paul Doherty.* 85 full-color and black-and-white illustrations. 26 diagrams. Outsized. **$16.95**

80500-2. THE STATE OF THE UNIVERSE. *Edited by Geoffrey T. Bath.* Eight astronomers' views. 125 illustrations. *Counts as 2 of your 3 books.* **$24.95**

64157-2. THE RAND-McNALLY NEW CONCISE ATLAS OF THE UNIVERSE. *Patrick Moore.* Nearly 1,000 illustrations. *Counts as 2 of your 3 books.* **$29.95**

58470. LIFE BEYOND EARTH. *Feinberg and Shapiro.* **$16.95**

32647-2. AMATEUR ASTRONOMER'S HANDBOOK. Fourth Edition. *J.B. Sidgwick.* Over 570 pages. *Counts as 2 of your 3 books.* **$25.00**

Astronomy Book Club
Riverside, New Jersey 08075
L-AJ6

Please accept my application for trial membership and send me either the three volumes indicated, billing me $1.00 each, or the **BASIC ASTRONOMY LIBRARY,** billing me only $3.00. I agree to purchase at least three additional Selections or Alternates over the next 12 months. Savings range up to 30% and occasionally even more. My membership is cancelable any time after I buy these three books. A shipping and handling charge is added to all shipments.

☐ Check here if you want the **Basic Astronomy Library-G (10160)**

☐ Check here if you prefer three other volumes for $1.00 each, and indicate below the numbers of the books you want.

A few expensive books (noted in book descriptions) count as more than one choice.

No-Risk Guarantee: If you are not satisfied—for any reason—you may return your introductory books within 10 days and your membership will be canceled and you will owe nothing.

Name________________________

Address________________________

City________________________

State____________Zip________

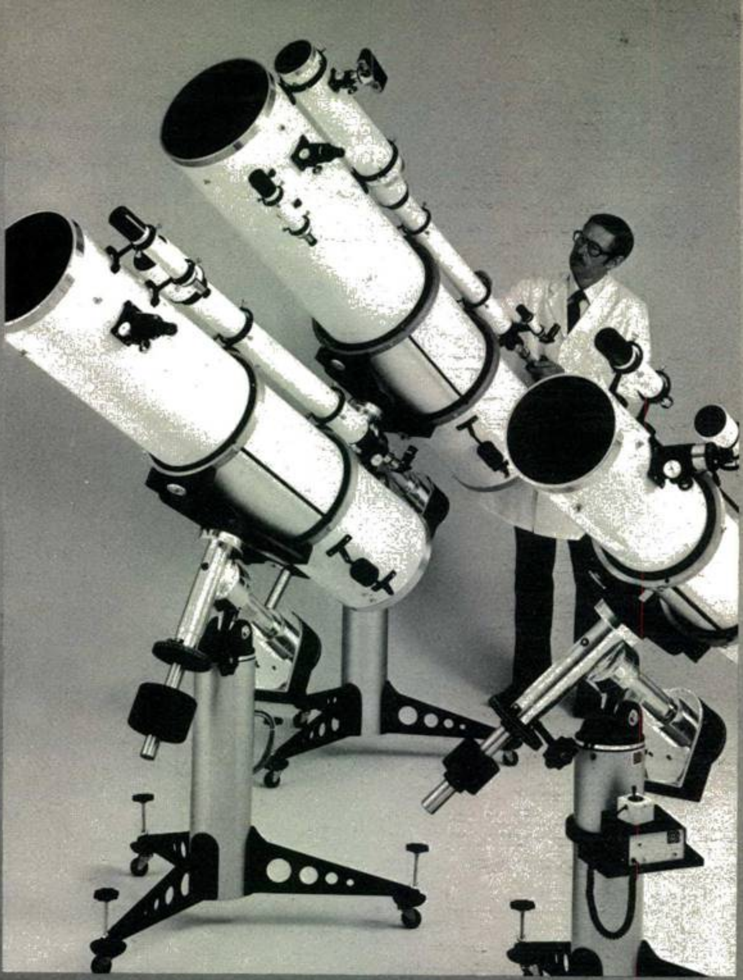
(Offer good in Continental U.S. and Canada only. Prices slightly higher in Canada.)

Meade precision photo-visual reflecting telescope systems

Large-aperture, high-resolution optics from the world's largest manufacturer of reflecting telescopes for the serious amateur.

Meade 6″, 8″, 10″, and 12½″ reflectors achieve a new level of optical and mechanical excellence for the serious amateur. These totally integrated telescope systems include everything required for detailed study of the Solar System and Deep Space, and readily permit the observer to grow into more advanced subjects, such as long exposure astrophotography.

Designed by Meade engineers and in continuous production at our Costa Mesa facility, these telescopes possess capabilities generally obtainable only at much higher prices — and they are the only telescopes available which use exclusively the quality Meade components known throughout the astronomical world.

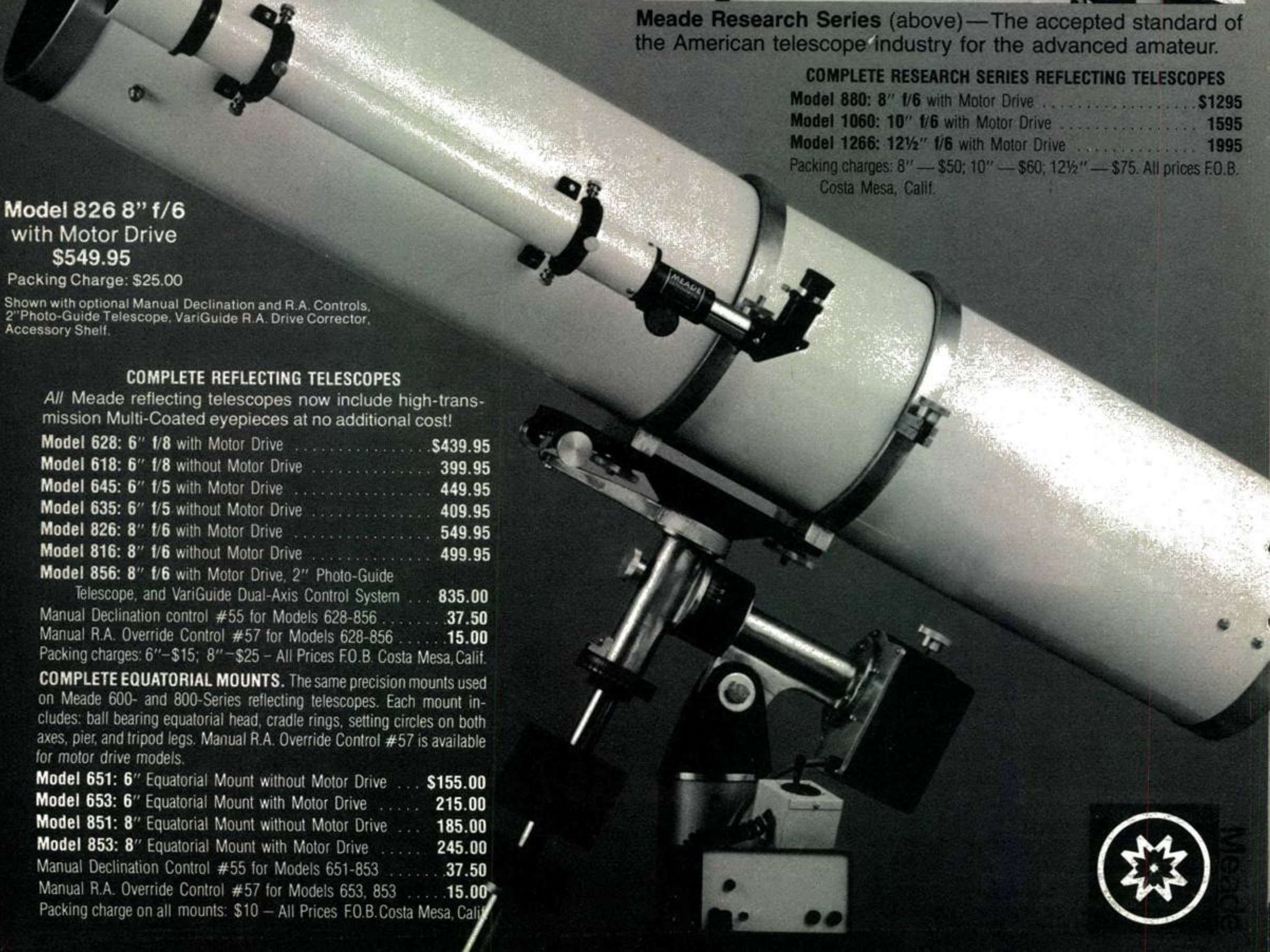


Meade Research Series (above)—The accepted standard of the American telescope industry for the advanced amateur.

COMPLETE RESEARCH SERIES REFLECTING TELESCOPES

Model 880: 8″ f/6 with Motor Drive	**$1295**
Model 1060: 10″ f/6 with Motor Drive	**1595**
Model 1266: 12½″ f/6 with Motor Drive	**1995**

Packing charges: 8″ — $50; 10″ — $60; 12½″ — $75. All prices F.O.B. Costa Mesa, Calif.



Model 826 8″ f/6
with Motor Drive
$549.95
Packing Charge: $25.00

Shown with optional Manual Declination and R.A. Controls, 2″Photo-Guide Telescope, VariGuide R.A. Drive Corrector, Accessory Shelf.

COMPLETE REFLECTING TELESCOPES

All Meade reflecting telescopes now include high-transmission Multi-Coated eyepieces at no additional cost!

Model 628: 6″ f/8 with Motor Drive	**$439.95**
Model 618: 6″ f/8 without Motor Drive	**399.95**
Model 645: 6″ f/5 with Motor Drive	**449.95**
Model 635: 6″ f/5 without Motor Drive	**409.95**
Model 826: 8″ f/6 with Motor Drive	**549.95**
Model 816: 8″ f/6 without Motor Drive	**499.95**
Model 856: 8″ f/6 with Motor Drive, 2″ Photo-Guide Telescope, and VariGuide Dual-Axis Control System	**835.00**
Manual Declination control #55 for Models 628-856	**37.50**
Manual R.A. Override Control #57 for Models 628-856	**15.00**

Packing charges: 6″–$15; 8″–$25 – All Prices F.O.B. Costa Mesa, Calif.

COMPLETE EQUATORIAL MOUNTS. The same precision mounts used on Meade 600- and 800-Series reflecting telescopes. Each mount includes: ball bearing equatorial head, cradle rings, setting circles on both axes, pier, and tripod legs. Manual R.A. Override Control #57 is available for motor drive models.

Model 651: 6″ Equatorial Mount without Motor Drive	**$155.00**
Model 653: 6″ Equatorial Mount with Motor Drive	**215.00**
Model 851: 8″ Equatorial Mount without Motor Drive	**185.00**
Model 853: 8″ Equatorial Mount with Motor Drive	**245.00**
Manual Declination Control #55 for Models 651-853	**37.50**
Manual R.A. Override Control #57 for Models 653, 853	**15.00**

Packing charge on all mounts: $10 – All Prices F.O.B. Costa Mesa, Calif.

Meade

Research level telescope parts and accessories from America's No. 1 supplier to the serious amateur

RACK-AND-PINION FOCUSERS—Precision metal construction. All 3 models include helical-cut rack and variable-tension adjustment for ultra-smooth focusing without backlash. Universal bases fit all tube sizes. Standard 1¼" eyepiece holders. **Each focuser is guaranteed to be the finest obtainable in its class:**

1—MODEL 67—Strong, lightweight design for 4" to 10" telescopes. 2-3/16" travel. An excellent value. **$23.75 ppd.**

2—MODEL 640—A heavy-duty deluxe focuser for 6" to 16" telescopes. Full 3" travel for both visual and photographic applications. **$39.95 ppd.**

3—MODEL 680—Our finest focuser. Accepts both 1¼" and 2" eyepieces. Full 3" travel for photo or visual observing with 6" to 16" telescopes. **$49.95 ppd.**

4—NEBULAR FILTER—This revolutionary 3-channel filter effectively blocks sodium and mercury emissions from city lights as well as natural airglow, while transmitting 90% of critical visual nebular emissions. Dramatically improves telescope performance visually and photographically. Hermetically sealed, anti-reflection coated. 23mm clear aperture. Threads directly into all Meade 1¼" O.D. eyepieces. **$59.95 ppd.**

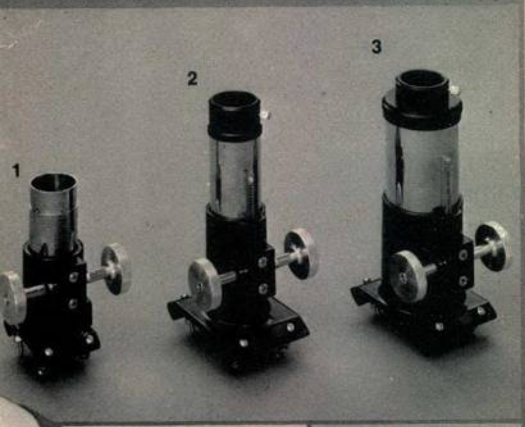
5—PHOTO-VISUAL COLOR FILTERS—Top quality optical glass, dyed-in-the-mass, with excellent spectral homogeneity. Mounted in machined metal cells which thread directly into all our 1¼" "Series 1", "Series 2", and "Research-Grade" eyepieces. Filters may be piggybacked. Listed by Wratten No. and color: **#8 Light Yellow—#11 Yellow-Green—#12 Yellow—#21 Orange—#23A Light Red—#25A Red—#47 Violet—#58 Green—#80A Blue—Polarizer (30% transmission).** Each filter: **$7.95 ppd.** Set of any 6: **$44.50 ppd.**—Full set of 10: **$73.50 ppd.**

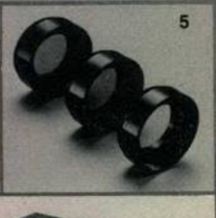
6—VARIPAK DRIVE CORRECTOR—Model 43—A quality electronic guiding unit with supercompact (2" × 3" × 4") design. Fast-slow pushbuttons mounted on the power pack. Variable control for lunar, planetary, sidereal rates. Operates from 12 volts D.C., plugs into standard auto cigarette lighter. The 12-watt output is sufficient for most telescopes to 14" aperture. **$65.00 ppd.**

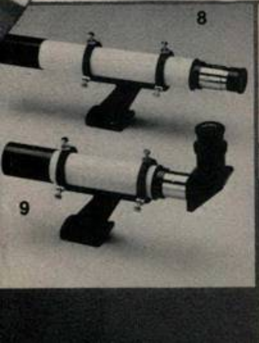
7—VARIGUIDE DRIVE CORRECTOR—Model 41—The finest R.A. drive corrector available. Includes aircraft-type joystick controller for continuously variable correction rates, not just "ON-OFF". May be used with any motor-drive-equipped telescope rated up to 12 watts, including most commercial telescopes to 14" aperture. Operates from 12 volts D.C. or 115 volts A.C./60Hz. Control box includes variable center-frequency settings for lunar, planetary, sidereal rates. **$119.95 ppd.**

8—6×30mm VIEWFINDER—Fine wide-field finder, the same unit supplied as standard equipment on Meade 6" and 8" reflecting telescopes. Actual field-of-view in excess of 4°. Includes coated, achromatic objective lens and crosshair eyepiece. Precise push-pull focusing. Thousands now in use. 2-ring bracket, with collimation screws and lock-nuts, included. Bracket fits all tubes 6" to 12½". **$24.95 ppd.**

9—6×30mm RIGHT-ANGLE VIEWFINDER—As in (8), but with diagonal prism for convenient right-angle observations. Prism may be rotated through 360° for maximum viewing comfort. 2-ring bracket included. **$29.95 ppd.**







Multi-Coated Series 2 and Research-Grade Eyepieces

Manufactured to entirely new Meade designs, these Series 2 eyepieces are a significant advance in eyepiece technology. Utilizing modern high-density optical glasses, each eyepiece has been computer optimized to yield the highest level of optical performance obtainable within its design class. **Air-to-glass surfaces on all Series 2 and Research-Grade eyepieces are Multi-Coated for maximum light transmission and image contrast.** All 1¼" barrels are threaded for Meade filters.

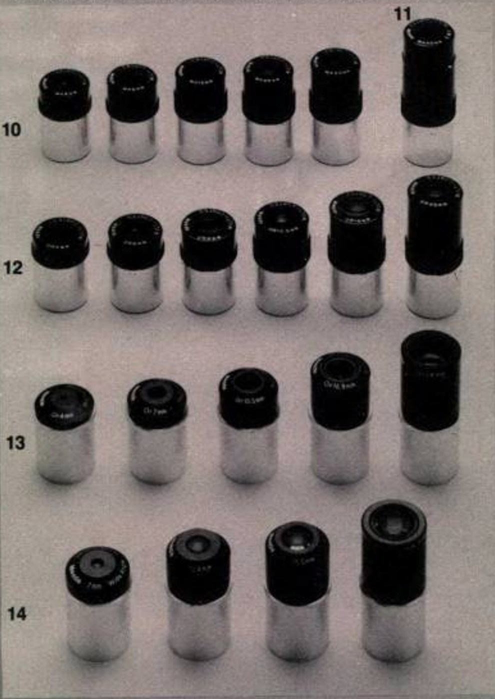
10—SERIES 2 MODIFIED ACHROMATIC EYEPIECES (1¼"O.D.; MULTI-COATED)—Fine 3-element systems, precisely corrected for chromatic and spherical aberrations. Guaranteed to be the finest eyepieces obtainable in their price class.
FOCAL LENGTHS: MA 6, 9, 12, 25mm and 40mm Wide-Field .... each $19.50 ppd.

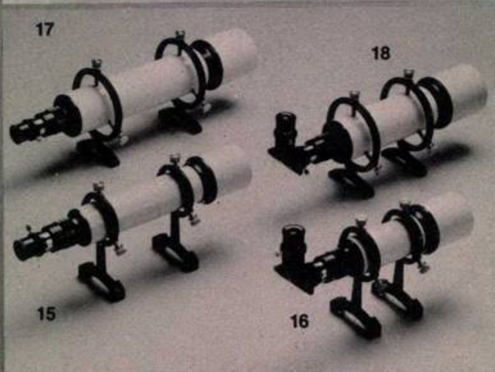
11—MODIFIED ACHROMATIC 40mm EXTRA-WIDE-FIELD EYEPIECE (1¼" O.D.; MULTI-COATED)—Yields widest field obtainable in 1¼" O.D. Enlarged field lens and special field-flattening optics with long eye relief. **$27.75 ppd.**

12—SERIES 2 ORTHOSCOPIC EYEPIECES (1¼" or .965" O.D.; MULTI-COATED; PARFOCAL)—The excellent 4-element high resolution optics of these oculars are all that the majority of serious amateurs will ever require. Razor sharp 45° fields. Both the 1¼" and .965" O.D. sets are accurately parfocalized.
FOCAL LENGTHS: OR 4, 6, 9, 12.5, 18, and 25mm...each $27.95 ppd.

13—RESEARCH-GRADE ORTHOSCOPIC EYEPIECES (1¼" O.D.; MULTI-COATED; PARFOCAL)—The largest selling premium-quality eyepieces in the world, universally acclaimed to be the finest eyepieces obtainable. These 4-element systems are unsurpassed in color correction, resolution, and flatness of field. 45° field. Accurately parfocalized.
FOCAL LENGTHS: OR 4, 7, 10.5, 16.8, 28mm...each $44.50 ppd.

14—RESEARCH-GRADE ERFLE EYEPIECES (1¼"O.D.; MULTI-COATED; PARFOCAL)—For breathtaking wide-angle observations. 65° fields, parfocalized with our Research-Grade Orthoscopics.
FOCAL LENGTHS: ER 7, 12.4, 15.5, 20mm...each $49.50 ppd.





VIEWFINDERS—With helical focusers for ultraprecise control of image sharpness. Coated, achromatic objectives of new Meade design yield fully corrected images throughout the field. Actual field on 50mm models: 4¼°; on 60mm models: 3½°. Crosshair eyepiece, dewcap, dustcap included. The 60mm models are particularly recommended for telescopes 8" and larger, where the large finder aperture is a tremendous aid in the location of faint objects.

15—8×50mm—$47.50 ppd. Brackets: **$7.95/pr. ppd.**

16—8×50mm RIGHT-ANGLE—$54.50 ppd. Brackets: **$7.95/pr. ppd.**

17—GIANT 9×60mm—$72.00 ppd. Brackets: **$12.75/pr. ppd.**

18—GIANT 9×60mm RIGHT ANGLE—$79.00 ppd. Brackets: **$12.75/pr.**

19—RESEARCH-GRADE ERFLE 32mm EYEPIECE (2"O.D.; MULTI-COATED)—Wide-angle, fully-corrected 65° field. The finest eyepiece obtainable in 2" barrel. **$110.00 ppd.** Adapter Barrel for 1¼"O.D. ... **$12.50 ppd.**

20—DELUXE CAMERA ADAPTERS—Adapt your camera to telescope focuser instantly. Individually machined from solid bar aluminum and brass. All units permit both eyepiece-projection and first (prime) focus photography. Specify either 1¼" or .965" focuser. All 1¼" units are threaded for our filters. **Pentax, Yashica, Mamiya...$22.50 ppd.—Nikon, Canon, Minolta, Pentax K, Exakta, Konica, Olympus OM-1, OM-2...$29.75 ppd.**

21—2X TELENEGATIVE AMPLIFIER (1¼" O.D.; MULTI-COATED)—Model 122: Warranted without qualification to be the world's finest Barlow lens. Full 26mm clear aperture, Multi-Coated, with virtually flawless optical corrections at all photo-visual wavelengths. Produces optimum performance on telescopes of any focal ratio...**$29.50 ppd.** **Model 131:** Per Model 122, but for .965" focusers; 18mm clear aperture, Multi-Coated...**$24.50 ppd.**

22—2X-3X VARIABLE TELENEGATIVE AMPLIFIER (1¼" O.D.; MULTI-COATED)—Model 127: Manufactured to the same research standards as the Model 122 above, but mounted in a precisely machined sliding cell, to permit variable power settings between 2X and 3X. Engraved scale indicates power. Multi-Coated...**$39.95 ppd.**

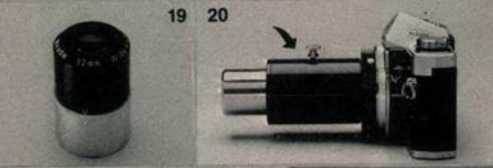
23—PARABOLIC MIRRORS—The very finest. 1/10-wave, diffraction-limited primary mirrors. Aluminized and quartz overcoated. Immediate shipment.
6" f/8...$65.00 ppd.; 6"f/5...$75.00 ppd.; 8" f/6...$95.00 ppd.; 10" f/6...$175.00 ppd.; 12½" f/6...$295.00 ppd.

24—SECONDARY MIRRORS—Elliptical 1/10-wave flats. Aluminized and overcoated. Immediate shipment. **1.30" M.A....$12.00 ppd.; 1.52" M.A....$16.00 ppd.; 1.83" M.A....$19.50 ppd.; 2.14" M.A....$23.00 ppd.; 2.60" M.A....$27.50 ppd.**

25—ILLUMINATED RETICLE GUIDING EYEPIECE (1¼" or .965" O.D.)—New phosphorescent etched double-line reticle permits line illumination from dim to extremely bright. Remote brightness control and 6 ft. cable. Modified Achromatic 12mm optical system. Precisely focusable reticle. Complete...**$49.95 ppd.**
Micrometer Reticle. Full-field scale for accurate measurements of double star separations, planetary angular diameters, etc. Interchanges with standard 4-line reticle...**$19.50 ppd.**

26—ERECTING PRISMS—Fully coated Porro prisms, for terrestrial observations with astronomical telescopes. **1¼" O.D. ...$32.95 ppd.**
.965" O.D. ...$27.95 ppd.

27—DIAGONAL PRISMS—Quality right angle prisms, fully coated. **1¼" O.D. ...$22.95 ppd.—.965" O.D. ...$16.95 ppd.**



Mail Orders: Write us your requirements—or use the order form which accompanies our catalog.
Telephone Orders: Accepted with payment either C.O.D. or credit card (we do not accept collect calls).
Payment: Personal or bank check, money order, or credit card (VISA or Master Charge).
Prompt Shipment: Our fast processing guarantees early delivery of your order.
California Residents: Add 6% Sales Tax. **Canadian Orders:** Add 10% to cover priority mail charges.
Foreign Orders (outside North America): Add 30% to cover Air Parcel Post charges. Payment must be made by bank check in US $.
General Catalog 81-C—$3.00 (Outside North America $5.00 for Air Mail). (Catalog free with any order.)

Card No. ______________________ Expiration Date ____ / ____ /
Name ______________________
Address ______________________
City ______________________ State ____________ Zip ____________

Meade Instruments Corporation 1675 Toronto Way, Costa Mesa, Calif. 92626 • (714) 556-2291

© 1980 Meade Instruments Corp. TM Series 2, Research-Grade, Fiberlite, VariGuide, and VariPak are trademarks of Meade Instruments Corp.

Bushnell Binoculars
Specially Priced For
ASTRONOMY Readers

The most portable and convenient way to observe the night skies...and anything else. ASTRONOMY offers discount prices on quality Bushnell instruments, featuring exclusive Insta-Focus for fast one-hand adjustment, rugged construction and excellent optics. And yes, the 7x35 and 7x50 can be used with one hand. All glasses are warranted and come with case, neck strap and lens caps.

The all-around glass. Light, study and portable. 5mm exit pupil, 37.5 Relative Light Efficiency, 1 year warranty.

7x50 Sportview®

High light-gathering ability makes this excellent for astronomy, but still small & light enough for general use. 7.1 mm exit pupil, 76.5 RLE, 1 year warranty.

$64.95

10x50 Explorer T.M.

The ultimate for astronomy, designed for tripod use under low-light conditions. 5 mm exit pupil, 37.5 RLE, 5 year warranty.

$139.95

To order use form between pages 60-61.

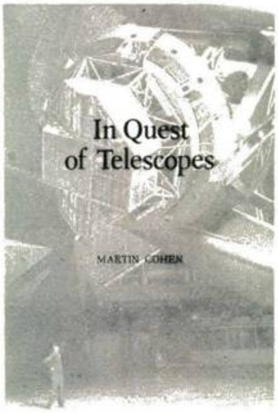
Thinking about making your own telescope? TELESCOPE MAKING is the only magazine in the world devoted to homemade telescopes, and it covers everything you need to know about them: design, optics, machining, mounts, testing, adjustment — even observatories! In four 48-page information-packed issues a year, you'll find everything you need to pursue this fascinating hobby — from the classic designs to the most daring new ideas. No matter how much (or how little) you now know about telescopes, there's plenty for you in every issue of TM.

$10 per year

Telescope Making
Circulation Dept.
P.O. Box 92788
Milwaukee, WI 53202

The book that tells it all . . . .

IN QUEST OF TELESCOPES by Martin Cohen



What's it like to be an astronomer? What type of work does one of them do? What influences a person to enter this field? And, not least important, what are the job prospects — especially today?

In an informal, yet highly informative autobiographical style, astronomer Martin Cohen describes his quest of telescopes from his backyard in England as a youngster to some of the world's largest in 13 observatories on three continents. He takes us along on his life journey through college in Cambridge, England, and into his new career in which his specialty became infrared astronomy, as part of his research into problems such as the birth of stars. We join Dr. Cohen on his nighttime observing sessions and get to see not only how it's done but also what life is like at a major observatory.

And just what is infrared astronomy? We find out about it as well as other modern aspects of the science. Any young person contemplating becoming an astronomer should read this book. It not only describes in detail the challenges and obstacles likely to be encountered (in a way no vocational guide ever did or could), but the easy conversational manner helps the reader decide whether the field would be enjoyable. *A most engaging and enjoyable work for anyone interested in astronomy.*

Order 46255 *COHEN* **$11.95**

SKY PUBLISHING CORPORATION
49-49 Bay State Rd. • Cambridge, Mass. 02238

IN QUEST OF TELESCOPES by Martin Cohen

Please enclose a check or money order for **$11.95** (payable to Sky Publishing Corp.) Mass. residents add 5% tax. Foreign add 10% for postage. **46255**

Name ....
Address ....
....
City ....
State .... Zip Code ....

july's lunar and solar eclipses

July has two special astronomical events in store. On the night of July 16/17, a partial lunar eclipse will be visible to most inhabitants of the western hemisphere (only those living north of about 60° will miss it). Half a lunation later, on July 31, observers in central and eastern Asia will see an excellent total solar eclipse.

The Lunar Eclipse

For most of our readers, this will be the main event for July. At maximum eclipse, just over half of the Moon's disk will be immersed in the darkest part of the Earth's shadow, the umbra.

To help us understand what we'll be seeing, let's look at the physical arrangement of Sun, Earth, and Moon. Sunlight falling on the Earth casts a shadow that extends some 1,370,000 kilometers out into space in a long cone behind our planet. Where this shadow crosses the Moon's orbit, the umbral cone has a diameter of about 9100 kilometers. You might think of the umbra as an invisible, skinny finger tracing the path of the ecliptic.

Since the Earth's umbra extends straight away from the Sun, we might expect to see Luna cross through it at each Full Moon. But we don't because the Moon's orbit does not follow the ecliptic — it's tilted about 5° to it.

When two orbital planes have a common center (the Earth in this case) and are tilted with respect to each other, they cross at two points which are called *nodes*. In its monthly orbit of the Earth, the Moon passes twice through the plane of the ecliptic. One passage — from south to north — is at the Moon's *ascending* node, and the other — from north to south — comes about two weeks later at the *descending* node.

Because the Earth's shadow always follows the ecliptic, the Moon can be eclipsed only when it lies on or near the ecliptic, hence the origin of the name. Since this happens only at the nodes, you won't see a lunar eclipse at every Full Moon — just whenever Full Moon and passage through a node coincide fairly closely.

But they do not have to coincide exactly, and there are two reasons for this. First, the 5° inclination of the lunar orbit keeps the Moon close to the ecliptic most of the time. Second, the Earth's umbra has a angular size of well over a degree. Both factors work to "loosen" the requirements for a lunar eclipse.

On July 17, Full Moon comes about 13 hours before the Moon reaches its descending node. As the diagram on the next page shows, the Moon will lie too far to the north of the ecliptic for it to enter fully into the umbra. Instead, we'll see a partial eclipse. The diagram also shows an outer ring surrounding the umbra. This is the penumbra, a region where the Sun is partially eclipsed by the Earth.

The eclipse will begin when the Moon enters the penumbra at 2:05 UT on the 17th (10:05 p.m. EDT on the 16th). The onset of the penumbral phase is invisible, since (from the vantage point of an observer on the Moon) the Sun is eclipsed only a tiny amount when it begins. But later, as the Moon moves deeper into the penumbra, some darkening will begin on the southwestern part of the Moon's disk.

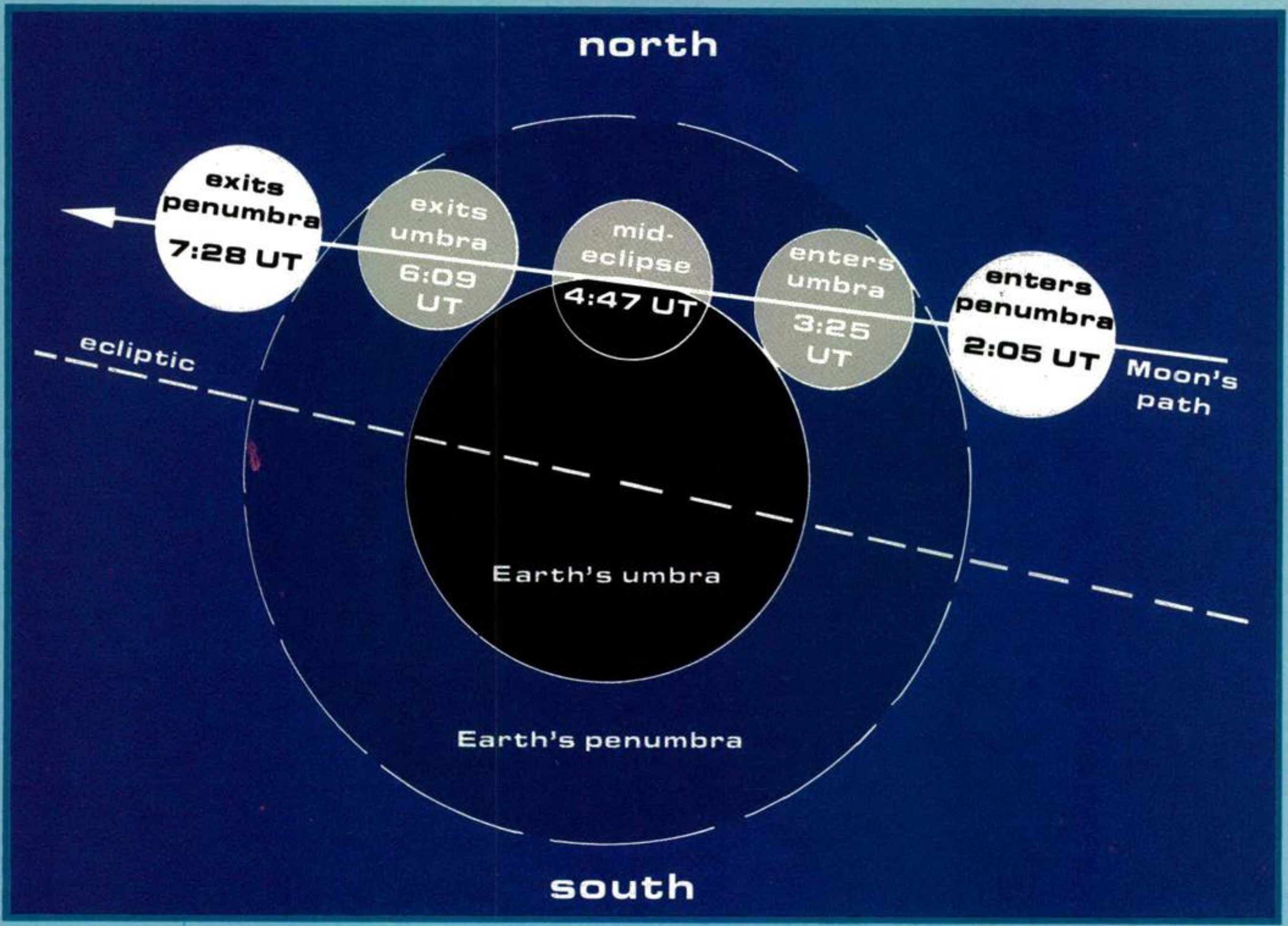
The first touch of the umbra comes at 3:25 UT (11:25 p.m. EDT). The point of contact will be 130° (measured counterclockwise) from the north point on the Moon's disk. Slowly and steadily, the curved edge of the Earth's shadow will creep across the face of the Moon — visible proof that our planet is indeed round!

Mid-eclipse happens at 4:47 UT (12:47 a.m. EDT on the 17th). At most, the umbra will cover 55.4% of the Moon's disk. The contrast in brightness between the northern half (in the penumbra) and the southern half (in the umbra) will be very pronounced.

At 6:09 UT (2:09 a.m. EDT), the Moon will leave the umbra. Its last point of contact will be 221° — again measuring counterclockwise from north.

The eclipse ends at 7:28 UT (3:28

photo by Helwig Schmook



Above: On July 16/17, the Moon's course takes it about halfway into the Earth's shadow. Right: Raynard Bagdis' photo of the February 26, 1979 solar eclipse shows a roughly circular corona surrounding the black disk of the Moon. Such coronal shapes are typical during the current years of maximum solar activity.

a.m. EDT) when the Moon exits the penumbra.

Observers on the east coast will get the best views — weather permitting, of course! For them, the Moon will be about 25° high in the southeast at the start of the umbral phase. By mid-eclipse, the Moon lies almost due south 29° high. When the umbral phase ends, the Moon is in the southwest, 27° high.

In contrast, from the west coast the same three events will be 3° high in the east-southeast (beginning of the umbral phase), 16° high in the southeast (at mid-eclipse), and 27° high in the south-southeast (by the end of the umbral phase).

Predicting what color the umbra-eclipsed parts of the Moon will be is tricky. Total eclipses in the past have varied in color from plain grey to yellowy to ruddy copper, depending on how much dust happens to be in the Earth's atmosphere at the time. What we'll see this time is anyone's guess.

The classic way to photograph lunar eclipses is to place a camera with a wide-angle lens on a tripod and aim it so the Moon will traverse the field of view during the eclipse. Take a series of exposures — one every 5 minutes, say — all on the same frame. This usually yields a dimly lit landscape in the foreground, a midnight-blue sky, and a series of Moon images that record its passage in and out of the Earth's shadow.

With 400 ASA film, a good shutter and f/stop combination is ¼ second at f/2. This should record some color (if there is any) in the umbra, but will overexpose the penumbral parts a great deal! Check your owner's manual for instructions on taking double exposures.

If you have a telescope with an equatorial mounting, piggyback the camera and lens on it. Turn on the drive and follow the stars. Take exposures at (1) the start of the penumbral phase, (2) about 15 minutes after the start of the umbral phase, (3) mid-eclipse, (4) 15 minutes before the Moon leaves the umbra, and (5) at the last contact of the penumbra.

You'll be up most of the night, but if you do it right, the result will be a stunning photo-version of the diagram above.

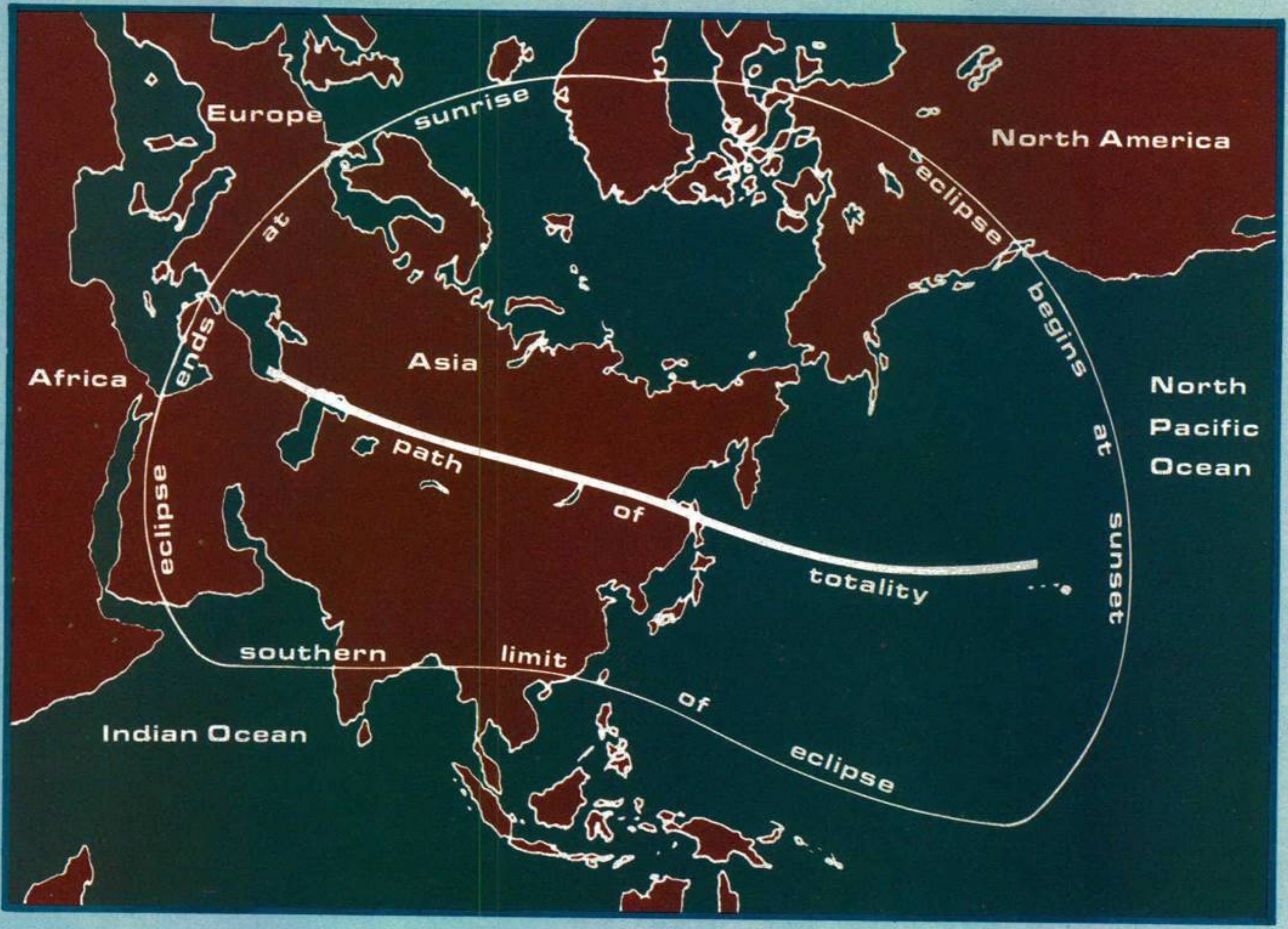
Siberia's Solar Eclipse

July's other big event takes place two weeks later and half a world away. On July 31, Soviet Central Asia and southern Siberia lie in the path of a total solar eclipse with a maximum duration for totality of 2 minutes 6 seconds.

While lunar eclipses are widely visible, total solar eclipses aren't. The explanation, once again, lies in the physical arrangement of the three bodies: Sun, Earth, and Moon.

Just as with lunar eclipses, an essential requirement of a solar eclipse is a New Moon that occurs at or near one of the Moon's orbital nodes — only then will the Moon lie close to the ecliptic. (This eclipse happens about 10 hours after the Moon passes its ascending node.)

The Moon's shadow reaching the Earth is the second requirement. While the Earth's umbra sticks out well past the lunar orbit, the Moon's umbra has a length of only about 374,000 kilometers. Since the Moon's distance can range between 356,400 and 406,700 kilometers, there are times — even if other conditions are right — when the *umbra won't reach all the way to the* Earth. (We then see an *annular* solar eclipse — so-called because an



The path of the July 31 total solar eclipse will sweep eastward from the Black Sea through Siberia to the Pacific Ocean north of Hawaii. Observers in the path of totality will see the Sun covered up completely by the Moon; those off the path but inside the indicated boundaries will see the Moon cover part of the Sun.

annulus, or ring, of Sun surrounds the disk of the Moon.)

On July 31, Earth is about 4 weeks past aphelion, so the Sun appears very nearly its minimum size. A "small" Sun means a longer lunar shadow — in this case, long enough to reach the Earth.

The path of the July 31 eclipse starts at the eastern end of the Black Sea at 2:18 UT (all times are for maximum eclipse). Moving northeast, the shadow crosses the Caucasus Mountains and the northern end of the Caspian Sea. By 2:21, the shadow has started across the steppes of Kazakhstan. There the altitude of the eclipsed Sun will be 11° and totality will last 56 seconds.

Maintaining a northeastern course as it heads toward southern Siberia, totality sweeps out a path some 95 kilometers wide. In its course, the shadow of the Moon passes over many Siberian villages, towns and cities. Slavgorod, near the southern limit, has mid-eclipse at 2:36 with the Sun 30° high; totality lasts 1 minute 10 seconds. Lying practically on the center line, Kamen'-na-Obi experiences 1 minute 30 seconds of totality: the Sun is 32° high there.

Around 2:40, the Moon's shadow will pass south of the large city of Novosibirsk, where the Sun with be 98.9% eclipsed. Gradually turning toward the east, the path cuts south of Krasnoyarsk, whose inhabitants see an eclipse 99.7% total. About nine minutes later, the path reaches Bratsk (at 3:01) where the eclipse is total. The Sun will be 44° high, and totality lasts 1 minute 23 seconds.

Moving due east, the shadow's southern limit passes across the northern tip of Lake Baikal at 3:10. Fifteen minutes later, the center line of the eclipse passes over the aptly-named village of Srednyaya — Russian for "middle."

The location with maximum eclipse duration (2 minutes 6 seconds) lies in the mountains to the northwest of the tiny settlement of Tokur (53° 8′ N, 132° 54′ E); the time is about 3:45. The Sun will be 54° high in the south southwest.

The umbra leaves the mainland of Asia at 3:58 when it crosses the Tatar Strait to Sakhalin Island. Last landfall is in the northern Kuril Islands at 4:19. The path continues across the north Pacific in a southeastern direction. It crosses the International Date Line at 5:03.

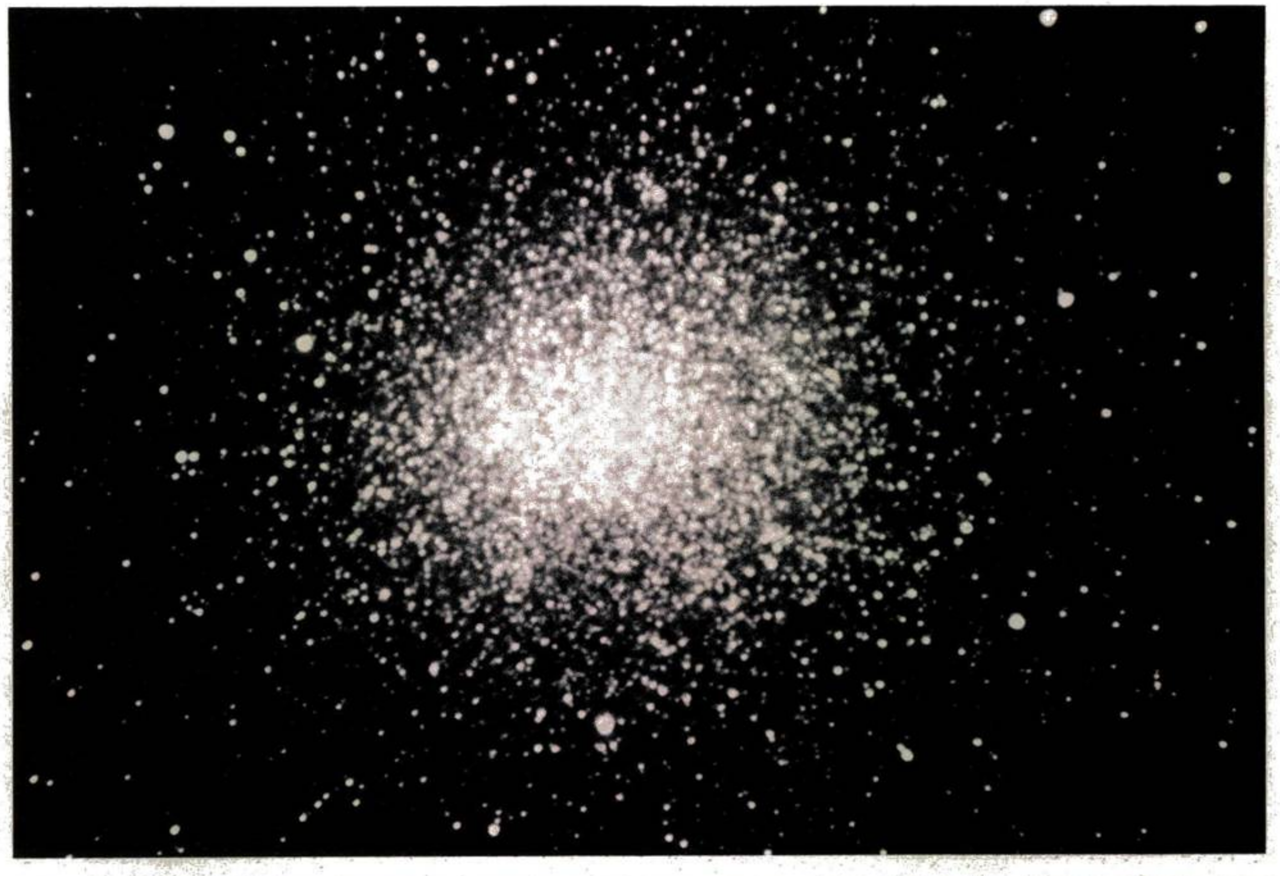
At sunset on July 30, observers in the Hawaiian Islands will see a 90% total eclipse as the path of totality passes by 500 kilometers to the north. The umbra leaves the Earth at 5:14.

The chances are good for seeing a number of planets and stars during totality. The brightest at magnitude -3.4, Venus will be very easy to find, 30° to the east of the Sun. Mercury (magnitude +1.2) will be 10° west of the Sun and just below the stars Castor (+1.3) and Pollux (+1.2). Jupiter (-1.4) and Saturn (+1.2) will be on the horizon in the east. Dimmish Mars (+1.8) won't be easy to see, though it will be high in the south.

Regulus (+1.3) will lie about 21° east of the Sun — not far from Venus. Rigel, Betelgeuse, Sirius, and Procyon also may be visible in the south.

The chances for clear skies are relatively good over the steppes and in southern Siberia, but average rainfall increases as you go eastward; clouds are cumulus for the most part. The average daytime temperatures range between 75° and 85° Fahrenheit in Kazakhstan but are 20° cooler in eastern Siberia.

— *Robert Burnham*



THE QUESTAR® 7 PHOTOGRAPHS OMEGA CENTAURI

This remarkable photograph of Omega Centauri was taken at Apache Pass, Arizona, by Hubert Entrop. He writes us "The wind blew from the west in strong gusts but I located in a low north-south arroyo beside a large bush to protect the scope. The atmosphere was miserably rough but in spite of it, it's a good Omega Centauri. Imagine what it would be like if we could have it straight overhead instead of so low on the horizon. Exposure 1 hour 30 minutes on Tri-X."

© Questar Corporation 1981

If you come past Questar these days you will see the newest feature on our landscape—the Observa-Dome, which we are now privileged to offer to our customers in a variety of sizes. It is equipped with the new Questar Telescope Mount which accommodates our Questar 12 and is engineered to support a telescope as large as 20 inches. The design of the mount is an adaptation of the German equatorial, with special Questar features that contribute to the mechanical perfection for which Questar products are noted. Unlike some recently introduced mounts, it has a full 360° continuous following capability, with a smoothness of operation that must be experienced to be believed.

Also at Questar, if you have an interest in surveillance or special tracking applications, you will see our patented 40-120 on display. This unique instrument establishes prime focus at both 40 and 120 inches (1000 and 3000 mm.) It resolves 100 lines per millimeter at the lower focal length and at least 55 lines per millimeter at the upper; one can move in a few seconds between the two and since the shift is managed by internal optical change the barrel length remains at a constant 30 inches. It weighs only 40 pounds.

In many ways the Questar 40-120 is the most sophisticated of the Questar instruments. Its size and weight make it ideal for a variety of uses where the observer must be at a great distance from the area or activity under scrutiny, while the dual focal length is particularly important for objects in motion.

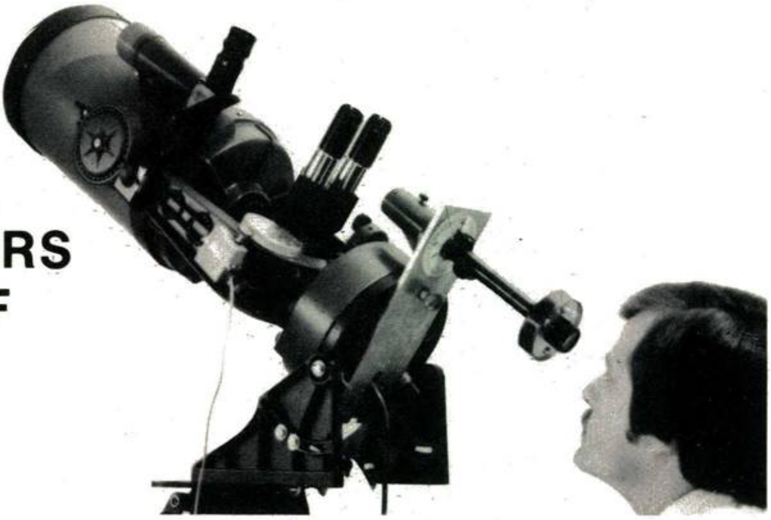
Literature on the Questar 40-120 and on the Observa-Dome is available on request.

• • •

A convenient accessory for taking deep sky photographs is an auxiliary guiding system, the Questar Starguide. It consists of a Tracker and Declination Vernier Drive. The Tracker intercepts light from a guide star and delivers it to the guiding eyepiece, and the Drive permits corrections on a 10 to 1 ratio over the existing, extremely accurate, Questar drive. The eyepiece can be swiveled 360° for comfort in guiding and is completely independent of the camera position.

QUESTAR, THE WORLD'S FINEST, MOST VERSATILE TELESCOPE IS DESCRIBED IN OUR BOOKLET IN COLOR, WITH PHOTOGRAPHS BY QUESTAR OWNERS. SEND $2 TO COVER MAILING COSTS ON THIS CONTINENT. BY AIR TO SOUTH AMERICA, $3.50; EUROPE AND NORTH AFRICA, $4; ELSEWHERE $4.50. INQUIRE ABOUT OUR EXTENDED PAYMENT PLAN.

QUESTAR
BOX C, DEPT. 81, NEW HOPE, PA. 18938
PHONE (215) 862-5277



ATTENTION ALL CELESTRON OWNERS AND OWNERS OF OTHER FINE COMPOUND TELESCOPES

Kerry D. Martin shown aligning his Celestron 8 with OUR Celestial Polar Axis Finder Now recognized by United States Patent Department with Patent # 4,260,253.

Wouldn't you like to have:

- A larger finder that would gather more light, be usable right angle or straight thru, take standard 1¼" eyepieces for varying the power, and still be collimatable with finger-tip adjustment without tools?
- A means for accurately lining up on the Celestial Pole in the dark without leveling your tripod or knowing your latitude and do it in less than two minutes so your setting circles will be accurate?
- Have a slow motion adjustment for the R.A. so you can make more accurate and convenient adjustment to match the slow motion in Dec.?
- A really light weight effective dew cap either heated or unheated for continuous and automatic dew rejection?
- A combination wedge and tripod adjustable in height and still light in weight and more stable?
- A SAFE Solar Filter recognized by the USA Patent Office which does not use magnets or glue and gives views of the tiniest sun spots without any aberration-producing openings and includes a filter for your finder as well so it too is SAFE?
- A large Digital Display of RA and Dec. with 6 times the accuracy of the normal mechanical circles or Computer control of both axes?

EVERY Celestron Telescope would operate with less hassle when fitted with these unique accessories.
NO GIMMICKS — all made to help the beginner.

DON'T BE AFRAID — Our Mail Order shipments to any place in the world are shipped in special containers. If by remote chance the scope arrives damaged, we ship you a new one and WE handle the claim with the shipper — YOU don't. In addition we give you our unique lifetime guarantee on the C-8 motors. **WE EXPORT SCOPES WITH ANY VOLTAGE AND FREQUENCY FOR EITHER HEMISPHERE.**

Do you feel in need of an astronomical friend? Call me. I would be glad to help you. I love astronomy and wish everyone did.
Roger W. Tuthill

Send a LARGE (8½" x 11") BROWN Self-Addressed Stamped Envelope (2 oz.)
Our new FREE catalog which illustrates all our unique aids to your great hobby:

Call us for the strong points of Dynamax, Meade, *Questar, Quantum* and Celestron Scopes.

WE REPAIR CELESTRON SCOPES
Telephone: 201-232-1786
(N.Y.) 212-926-6498
(L.I.) 516-794-2050

Master Charge, VISA
*Trade Mark

ROGER W. TUTHILL, INC. **Box 1086A, 11 Tanglewood Lane, Mountainside, N.J. 07092**

TIRED OF WIGGLY EQUATORIAL TELESCOPE MOUNTS?

GIVE YOUR SCOPE THE TUTHILL I.Q.* TEST

Use a string to hang a one pound weight on your scope focus knob. Put in a 12mm eyepiece and cut the string with scissors. Time how long vibrations continue. With this test a Celestron 8 on our NEW Adjustable Height Isostatic Equatorial Wedge and Tripod Mount stops vibrating completely in less than ONE second!!! Some adjustable tripod/wedge combinations take up to 10 seconds to stop shaking.

If your scope stops vibrating in three seconds or less you can consider it acceptable. Write for information on our NEW adjustable height combination wedge and tripod which we call an Isostatic Equatorial Mount for Cassegrain scopes.

*I.Q. = Instability Quotient

A LOW COST FINDER FOR YOUR SCOPE

We supply a LOW cost finder for the ODYSSEY I Telescope. Yes we are now authorized dealers for this new FUN Telescope. We can even supply 50mm or 80mm right angle finders to complement the fantastic light-gathering ability of these new unique units. Come see them demonstrated. We can also supply Sun Filters too!!!

WHY CRIPPLE YOUR SCOPE?

Every telescope deserves a decent finder. Ours are a joy and pleasure to use. We have both 50-mm and 80-mm units as well as twin binocular types. They feature these benefits:

- Fingertip collimation — no tools
- Takes standard 1¼″ eyepieces
- Right-angle or Straight-through
- Two focusable eyepieces with metal crosshairs for low or high power
- Brilliant images sharp to the edge
- Fits any scope easily.

From $59

Recognized As Headquarters For Telescope Solar Filters

Solar-Skreen® Sun Filter

Blocks all heat before it enters your scope. Fits any size scope of any type. U.S. Patent No. 3,897,140. GUARANTEED SAFE: No glue or magnets used.

From $18.

Roger W. Tuthill
Dear Sir:

Usually letters to dealers are to register complaints. I think you deserve the opposite type. I placed two orders in the past few weeks and received both complete in 9 to 10 days (a pat on the back). The latitude adjuster for the DX-8 is the greatest idea since sliced bread. The f/5 telecompressor was also great, photographically and visually. No coma was noted at the edge of the field (another pat on the back). However your greatest contribution to the world of amateur astronomy has got to be the "Precision Polar Axis Finder." I received mine last Thursday. It installed in minutes. Between it and the latitude adjuster, I had perfect alignment in two minutes. (The two star method never did work for me.) I took 5 and 10 minute exposures the first night with NO declination drift (two pats on the back). I wish other manufacturers cared as you seem to. Anyway, I feel your service and products are to be commended and you can be sure of repeat business.

Sincerely yours,

Joe Condiliere

Joe Condiliere
Glendora, CA

PRECISION POLAR AXIS FINDER*

Get perfect celestial pole alignment quickly and easily every time. When the centered 4x cross hairs are set directly on Polaris, the 0.8-degree offset barrel points precisely on the pole. Novel Polaris date and time chart supplied FREE.

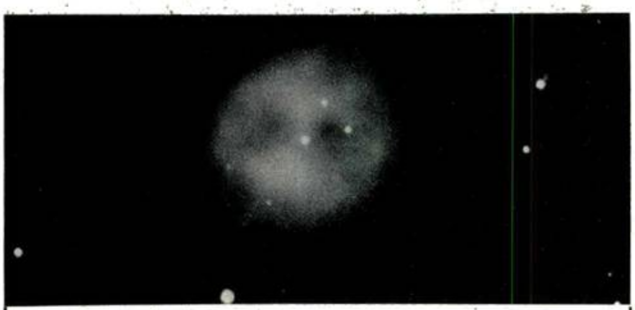
Celestron model or German Equatorial model $97.

Patent # 4,260,253

WE HONOR MASTER CHARGE AND BANKAMERICARD.
MONEY-BACK GUARANTEE ON ALL PRODUCTS WE SELL

Telephone: 201-232-1786 (N.Y.) 212-926-6498 OR (L.I.) 516-794-2050

ROGER W. TUTHILL, INC. Box 1086A, 11 Tanglewood Lane, Mountainside, N.J. 07092



GAS HYPERSENSITIZED #2415 M-97 Photo by Ron Potter

SUPER FILM

A LUMICON® HYPER-KIT™ made the above photo possible by gas-sensitizing ultra-fine grain 2415. You can do it too!

MODEL 300 FILM
HYPERSENSITIZATION KIT

LUMICON HYPER-KITS™ yield 3-30X true film* speed gains. **All** films benefit. Gas-hypered kodak film: 2415, **$8.95**; Kodacolor 400, **$9.95**; **Ektachrome EPD $9.95**

MODEL 100 HYPER-KIT™ for 35mm film. Safe, refillable gas bottle for 100 rolls. Takes longer but is easy to use! **$199.50**

MODEL 300 HYPER-KIT™ (see photo) sensitizes 35mm film in hours. Yields highest possible film speeds. Best for 2415 users **$249.50**

Model 600 HYPER-KIT.™ Similar to Model 300, but also sensitizes small glass plates and 120/220 large format film **$289.50**

Model 1200 HYPER-KIT™ for 4x5" plates or up to 5x7" film **$429.50**

LOW-PROFILE OFF-AXIS GUIDER*

The LUMICON EASY-GUIDER™ makes an instant astrograph! Ideal for Newtonians or Cassegrains. Fits 2" focus mounts in seconds. Performance is superior to units costing much more **$139.50**

DEEP-SKY FILTER for nebulae & galaxies, $59.50 (1¼" eye-pieces), $109.50 for 2" eyepieces & photography.

(415) 447-9570 (CA res. add 6% tax). *Patent Pending

LUMICON

Dept. A-3, 891 Laguna St., Livermore, CA 94550

Celebrate America's Triumph with a "Mission Columbia" Commemorative Stein

"Now we're close to going to the stars"
Astronaut Robert Crippen

On April 14, 1981, a ten year effort by thousands of Americans concluded triumphantly when astronauts Robert Crippen and John Young landed the Space Shuttle Columbia on a tiny patch of California desert. The event made space and aviation history: The first return from space of a piloted craft.

Now you can show your pride in this accomplishment for years to come with this attractive piece of art.

Each "Mission Columbia" commemorative stein is meticulously made and decorated in America and is capped with a heavy, polished pewter lid. Each will be bottomstamped:

"Mission Columbia"
April 12-14, 1981
#/9500

Total world edition: 9500 individually and serially numbered pieces.

Both investors and collectors alike will want to call or write promptly to reserve the very lowest numbers of the historic "Mission Columbia" first edition.

Issue price **$29.50**

SPACE SHUTTLE
SPACE CENTER

Mader's

**1041 N. 3rd Street, Dept. A,
Milwaukee, WI 53203
Gift Gallery (414) 271-1911;
Out of state call toll free:
1-800-558-7171.**

Mail and phone orders accepted with the use of your major credit card. Please add $3.00 shipping charge for first item; $ .50 each additional item.

S&S Optika, Ltd.

WORLD'S MOST USABLE STAR ATLAS

- 24-Page Full-Color Atlas of the Heavens
- 11"x 14" Plastic Finished Card Stock
- Luminescent Star Finder on Front Cover
- Table of Planetary Locations $7.75

VARIABLE FREQUENCY DRIVE CORRECTORS

- 25-Watt Output
- Solar, Lunar and Sidereal Presets
- Infinitely Adjustable Base Rate
- Instantaneous Add and Subtract Pulse Buttons
- Fully Grounded for Safety
- Includes 20', 12-Volt Car Cable
- 12-Volt DC or 115-Volt AC Operation

Single Axis $134
Dual Axis $169

PACKAGE #7

EDMUND 2001 ASTROSCAN:

- Rich-field, low power, 4" Telescope
- Comes with a 28mm RKE Eyepiece (16x)
- Great for wide-field scanning of the Heavens. Milky-way views are breath-taking.
- Included with Package #7 is our 24 page Star Chart.

Total Price $189.00

Celestron's optical and mechanical engineering for portability, versatility and ease of operation has made the Celestron the most popular telescope value for the money on the market today.

S & S Optika offers 2 Service Packages on the Celestron 5" or 8". C-8 base prices from $845.00 to $995.00. Please write or call for further details.

WEATHERPROOF ACCESSORY CASE

- Carries Six Eyepieces, Diagonal, Telextender, Telecompressor, Filters etc. (Not included) $14

MICRO-FINE LATITUDE ADJUSTER

For Celestron Telescopes

- Full Latitude Control at Your Fingertips $19

MICRO-GUIDE

- Output-Frequency Continuously Variable from 50-70 Cycles
- 6 Watt Grounded Output Can Drive a Celestron 8
- NASA Spec Circuit Board
- 15' of Battery Cable $39

Colorado residents add 3% tax. If you send check or money order, we pay shipping in continental USA only. Shipping extra on credit card and COD purchases. Outside USA, shipping additional—write before ordering.

S&S Optika, Ltd.

**3855 S. Broadway
Englewood, CO 80110
Telephone (303) 789-1089**

Send me FREE INFORMATION about S & S Optika Products. ☐
Also available— 32 page Celestron Color Catalog — $2.00 ☐
Dealers for Celestron, Edmund, Unitron, Meade & Pentax.

Name ______
Address ______
City ______ State ______ Zip ______
Telephone & Area Code ( ) ______ **Dept. A**

Celestron® C30 Zoom Spotting Scope

• FOR BEGINNING ASTRONOMY • NATURE STUDIES • VIEW HOME • SPORTING EVENTS

With this Celestron you can see • craters on the Moon • the moons of Jupiter • Nebulae and Galaxies • candid views of animals • distant action at sporting events • distant objects from a view location

- 10 to 30 power zoom
- 30mm aperture
- coated achromatic objective
- compact size (12¼ inches long)
- large eye relief
- metal construction
- light weight (11 oz.)
- $75.00 suggested retail price
- ¼ x 20 adaptor for photographic tripods
- table top tripod included with instrument

Extreme portability allows usage anywhere

The Celestron Zoom Spotting Scope is a complete self-contained telescope which needs no other accessories for its enjoyment. The Celestron Zoom Spotting Scope gives sharp views of objects in the sky or on the ground. Since you can focus from 20 feet to infinity, it also acts as a long distance microscope. The Celestron Zoom Spotting Scope is perfect for a young astronomer just beginning to study the sky; it will also give hours of satisfying viewing when it is turned toward terrestrial subjects on Earth. Bird watchers can use this highly compact and lightweight spotting scope for studies at long distances. This instrument is the only spotting scope offered by Celestron of other manufacture. The unit is imported to exacting Celestron specifications.

The Celestron Zoom Spotting Scope is intended only for visual studies of bright celestrial objects and all terrestrial subjects; photo adapters are not available. The clear bright images make this telescope a joy to own and use; the Celestron Zoom Spotting Scope makes an excellent gift to neophyte astronomers or terrestrial observers. Note that astronomical viewing is much better when done away from the smoggy and light-polluted air of a city with any telescope. If you are seriously interested in astronomical observing, we encourage you to inspect our other large aperture astronomical telescopes.

C30 shown used on a table with standard tripod

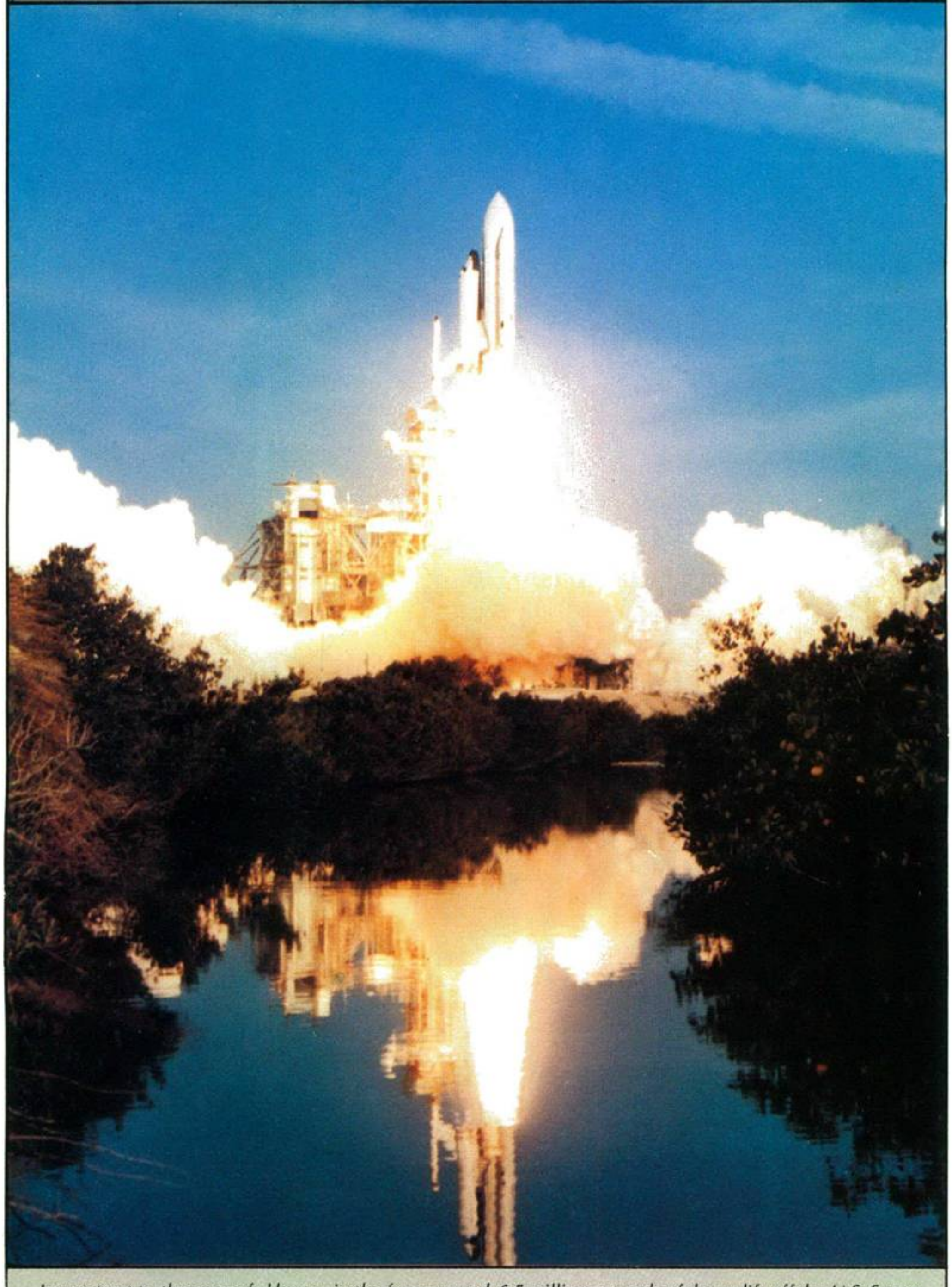
Celestron®

Celestron International
2835 Columbia Street A
Torrance, CA 90503 U.S.A.
(213) 328-9560

Send $3.00 for 48-page illustrated color catalogue on how to select and use a Celestron telescope . . . .

AstroNews

Halley Fund Announced at Shuttle Liftoff



5...4...3...2...1...Liftoff!

In contrast to the peaceful bayou in the foreground, 6.5 million pounds of thrust lift off the U.S. Space Shuttle Columbia *from the Kennedy Space Center at 7:00 a.m. EST, April 12. Thus began a successful journey aboard the Earth's first spaceship for astronauts John Young and Robert Crippen who touched down in the shuttle 54½ hours and 36½ orbits later at Edwards AFB in California.*

Just days before the successful launch of the Shuttle *Columbia*, Dr. Joseph Veverka, Cornell University comet expert, made an urgent appeal to the U.S. scientific community to support an American mission to probe Halley's Comet. He voiced his appeal in Cocoa Beach, Florida. At the same press conference the formation of The Halley Fund — a last ditch effort to secure an American probe — was announced by Van R. Kane, director of the fund.

According to Kane, goals of the Fund are threefold:

- To demonstrate widespread public support for a U.S. mission.
- To encourage direct citizen participation in the exploration of this celestial object, observed from Earth for two millennia.
- To directly pay for some portion of U.S. efforts to explore Halley's Comet.

The fund is marshaling an 11th-hour effort to save the U.S. Halley Intercept mission (HIM) — the most sophisticated, scientifically-advanced comet mission contemplated by any nation at this time.

NASA budget cuts have eliminated formal plans for a U.S. mission to comet Halley as it approaches our Sun for the last time until 2062. "This," says Kane, "requires direct citizen action. Together with planetary scientists, we must underline the point: Halley cannot fly by unexplored by the U.S.

"With the launch of the space shuttle, we have new opportunities to explore our world, the solar system and the universe. A mission to Halley, launched by the shuttle, could even go on to a second comet, and would go a long way toward reversing our retreat from space."

The Halley Fund is a spin-off of another successful citizen effort — the Viking Fund — that has so far raised $100,000 from private citizens, high schools, churches, and community groups, at about $15 per contribution. The money, turned over to NASA in January 1981, is helping further the exploration of Mars through the Viking lander.

Kane continues: "While the Soviets, the Japanese, and Europeans through the ESA all plan to send spacecraft to meet Halley, the unique scientific value of a U.S. mission is unquestioned. Key measurements depend on navigating a spacecraft to within 600 miles of the comet's nucleus. Only a U.S. spacecraft would have the sophisticated navigation capability to guarantee such a close encounter. "Now our nation's only hope for exploration of Halley depends on Congress adding funds to NASA's fiscal year 1982 budget for a Halley Intercept Mission. If the funds are not added, it will be too late to build a spacecraft — even with spare parts left from other NASA missions — to meet Halley when it returns in 1985/86."

Dr. Joseph Veverka, chairman of NASA's Comet Science Working Group and member of the fund's advisory council says, "Perhaps the most fundamental reason for sending a spacecraft to a comet is that there are some 100 billion of them in our solar system, and so far we haven't explored a single one.

"Halley is the only large, active comet whose orbit is predictable enough to be investigated by spacecraft. Therefore, the 1986 apparation of Halley provides the one opportunity in our lifetime to carry out direct studies of this most important class of solar system objects."

Contributions to the Halley Fund should be sent to 357 Saratoga Ave., Santa Clara, CA 95050. All contributions are tax-deductible.

Minority Students at Kitt Peak

The National Science Foundation has awarded $24,000 to the Association of Universities for Research in Astronomy Inc. (AURA) to provide fellowships for nine American Indian, Hispanic and Black undergraduates to attend a summer program at Kitt Peak National Observatory.

The program is designed to encourage minorities to choose careers in astronomy or related scientific and technical fields. The nine undergraduates were selected from 30 applicants on the basis of evaluation by an advisory committee comprised on non-NSF scientists and educators.

Each student will work with KPNO staff members, collaborating in research involving telescope observations and data reduction. They will also attend a lecture course accredited by the University of Arizona.

The students chosen are: Donna Boyer, Boise (Idaho) State University; Pangie Burns, Jackson (Mississippi) State University; Stacie Hambric, Oberlin (Ohio) College; Christopher McDaniel, Sangamon State University (Illinois); Lauri Murdock, Morgan State University (Maryland); Gines Negron, University of Puerto Rico; Carmen Pantoja, University of Puerto Rico; Annabelle Quintana, New Mexico Highlands University, Las Vegas; and Trevor Tyson, Andrews University (Michigan).

Index

- Halley Fund Announced at Shuttle Liftoff
- 5...4...3...2...1...Liftoff!
- Minority Students at Kitt Peak
- Rock Clock
- U.S. Tests on Soviet Satellite
- 300" Passes First Test
- Meteorite Origins Questioned
- Radio Telescope for CTIO
- Probing Beyond the Galaxy
- Galileo Heatshield Tested

Rock Clock

Using a "mineral clock," two University of Chicago scientists have raised doubts about how our solar system cooled after condensing from a hot, swirling gas cloud 4½ billion years ago.

The researchers say that minerals in an ancient meteorite they studied were formed more than two million years after the solar system began to condense, and that these minerals were created at temperatures of more than 1,000 degrees. This is much hotter than scientists thought the solar system should have been so long after its formation.

"All of the theoretical models predict that the outer solar system, where the meteorites formed, should have cooled to less than 100 degrees by the time these minerals formed," says researcher Ian Hutcheon.

Hutcheon and Robert Newton found the minerals in the most primitive part of the meteorite — a small white pocket of minerals called an inclusion. Inclusions are thought to be the oldest material in the solar system, and have already told scientists much about the birth of the Sun and planets.

Hutcheon and Newton used the minerals as both a thermometer and a clock for the early solar system. First they determined that one radioactive mineral — aluminum 26 — formed at about 1300 degrees Fahrenheit. Then, to find *when* it formed, they searched for its "daughter" — magnesium 26 — that would be formed when aluminum 26 decayed.

The radioactive aluminum was present in the primitive inclusions when they formed and it contaminated the inclusions with magnesium 26 when it decayed. But in the mineral itself, the researchers found less than one-tenth as much magnesium 26 as in the rest of the inclusion, so the mineral did not form until the aluminum 26 had all but disappeared.

That required at least 2½ million years, say the Chicago researchers. "There is really no way to keep the entire solar system hotter than 1,000 degrees for that much time," Hutcheon says. "These inclusions, and perhaps other material, may have been insulated by burial under a deep layer of rubble on bodies the size of asteroids."

This burial may be the process that packed together inclusions and other material to form meteorites. But Hutcheon warns that our knowledge of the solar system's birth is still sketchy. "These are clues to when some parts of the solar system formed," he says. "These things are still very poorly understood."

Hutcheon and Newton measured the mineral's magnesium in their laboratory at the University of Chicago with a device called an ion microprobe. A thin beam of ions from the microprobe blasts atoms off the surface of the mineral grain and sends them into a mass spectrometer for analysis. The probe's ion beam is focused to less than one two-thousandth of an inch in diameter. It is one of only a few such devices in the world with the precision to study single mineral grains in meteorites.

U.S. Tests on Soviet Satellite

Fourteen United States experiments, launched in fall 1979 aboard the unmanned Soviet satellite Cosmos 1129, have yielded valuable information about the effects of weightlessness on physiological processes.

U.S. experiments detected changes in enzymes and in animal bone strength, growth rate, and mineral content similar to some changes experienced by astronauts and cosmonauts. These findings have brought new explanations for some of the problems of weightlessness.

The Vostok spacecraft, which was launched into an elliptical orbit and recovered 18½ days later within the Soviet Union, was similar to those used on two previous Cosmos missions in 1975 and 1977, in which the U.S. also participated. Cosmos is inexpensive for U.S. experimenters because the cost of the spacecraft and support activities is borne by the Soviet Union. Cosmos has also offered U.S. experimenters their only opportunities since 1975 for biological research in space.

AstroNews

After the Cosmos flight, the animals were recovered immediately, before they could readapt to Earth gravity. The Soviet recovery team moved rapidly to the landing site and set up a mobile laboratory to perform autopsies on about one-fifth of the animals. The remaining animals were flown to Moscow, where some were autopsied after six days of readaptation to gravity, and the remainder after 29 days.

The next opportunity for U.S. participation in a Cosmos mission will be mid-1982. Tentative plans are for the United States to provide instruments to measure blood pressure and blood flow in two rhesus monkeys during a flight of about two weeks. Joint U.S./U.S.S.R. studies of the monkeys' metabolism, biorhythms and bone metabolism also are planned. The 1982 flight, the first Soviet attempt to place monkeys in orbit, will provide an opportunity to study the effects of spaceflight on an animal more similar to humans than the rat is.

300" Passes First Test

The 300-inch telescope proposed for the University of Texas McDonald Observatory, which would be the largest ground-based, single-mirror telescope in the world, has passed its first test. After a detailed study, a leading telescope manufacturer has pronounced the giant instrument "technically feasible."

"We always thought we could do it," said Dr. Tom Barnes, McDonald Observatory's assistant director. "Now we're sure we can," he added, referring to a report from the Western Development Laboratories Division of Ford Aerospace and Communications Corporation.

Last December, the UT System Board of Regents approved in principle the development of plans for the telescope and authorized McDonald Observatory to seek outside funds for the project.

"Public response was immediate and encouraging," said Dr. Barnes. One letter of support, he said, came from an eighth-grade science class in Paris, Texas, hometown of W. J. McDonald, the observatory's first benefactor and the man for whom it is named. The students enclosed a check for $34.58, and wrote: "We would feel honored to help in some way to construct the largest and most advanced telescopic instrument."

"Other individual well-wishers write daily," said Dr. Barnes, many with donations. The $20,000 the observatory has received so far "has been a great inspiration, as well as providing critically needed help at this time," he said. The 1981 price tag for the 300-inch giant is $45 million.

Just where will the observatory get that kind of money? "We know it will be tough," Dr. Barnes said, "but we're confident of success. Our director, Harlan Smith, has put a lot of work into developing our fund-raising plans."

With the help of the McDonald Observatory Advisory Council — "a high-powered group of successful Texans," according to Dr. Barnes — the observatory has formed an executive committee to spearhead the fund-raising. The committee will be working with the University, with foundations, "and with people all over the state who are able to help."

The $45 million total project cost is considered austere for an undertaking of such magnitude, according to Dr. Barnes. By taking advantage of recent advances in engineering and computer technology, UT astronomers estimate the 300-inch telescope will cost 10 times less than one built according to "classical" methods.

Although most of the proposed telescope is based on advanced but current technology, its major component, the 300-inch primary mirror, represents a revolutionary design. If the new telescope were to be built along the lines of the Russian 240-inch, now the world's largest telescope, or the 200-inch at Mount Palomar, the largest telescope in the United States, its mirror would have to be four to five feet thick and weigh 100 tons. But the 300-inch mirror will have a thickness — actually a *thinness* — of only four to five inches.

The thin-mirror plan was developed by UT astronomers with Dr. Aden Meinel of Tucson, one of the world's leading specialists in optics and telescope design. The result is an extremely light-weight telescope with a super-thin (by telescope standards) mirror, plus an electronics control system to "persuade the mirror to hold the correct shape," Dr. Barnes explained. Not only does the design make for a much less costly mirror, he noted, it also should provide better "seeing" ability.

"Thick mirrors," he said, "are nearly always out of equilibrium with the surrounding air temperature." This distorts the image of whatever the telescope is viewing. A thin mirror, on the other hand, can easily reach thermal equilibrium with the night air soon after the dome of the telescope is opened.

The design also calls for an extremely short focal ratio, making the telescope only twice as long as it is wide. That has definite cost advantages in the telescope construction, and the resulting smaller-sized dome will cost only one-eighth as much as a classical 300-inch telescope.

If the fund-raising goes according to schedule, UT astronomers hope to have the telescope built and operating by 1986. It will sit atop 6,000-foot Mount Fowlkes, about a mile north of Mount Locke, where McDonald's 107-inch, 82-inch, 36-inch, and 30-inch reflecting telescopes are located.

The remoteness of its location in the Davis Mountains of West Texas makes McDonald free of the light pollution that is brightening and ruining the sky for many other U.S. observatories, Dr. Barnes said. The skies over McDonald are the darkest above any major observatory in the continental United States, and among the darkest in the world.

Meteorite Origins Questioned

An anomaly detected in a primitive meteorite in 1973 has been found to be common to most meteorites, and perhaps at one time to most of the matter in the solar system.

The anomaly was found by University of Chicago chemists. Two of those researchers, Robert Clayton and Toshiko Mayeda, were among five scientists who reported the new findings at the Lunar and Planetary Science Conference in Houston.

They reported that the anomaly — an excess of oxygen 16 — may help to explain the formation of meteorites and similar material at the birth of the solar system. Their colleagues are J. L. Gooding and K. Keil of the University of New Mexico, and E. J. Olsen of the University of Chicago and Chicago's Field Museum of Natural History.

Clayton found the excess oxygen 16 by looking at the tiny spheres called chondrules that are found in most meteorites. He says that these spheres retain a "memory" of oxygen 16 excess that was lost by the rest of the meteorite through chemical processing.

Like other atoms, oxygen occurs in several different weights, or isotopes, depending on the number of neutrons that join the eight protons in its nucleus.

"It's important that the process responsible for enrichment of oxygen 16 has been found in essentially all meteorites rather than just certain types," says Clayton. The oxygen is believed to have come from a supernova that exploded near the solar system at the time of its condensation from gas and dust. Clayton says that the oxygen 16 excess and recent studies by the researchers of the iron content of chondrules provide several clues to the formation of meteorites and the chondrules themselves.

Meteorites are classified according to their iron content. But the researchers found that the iron and oxygen isotopic ratios in chondrules bear no relation to the iron in the meteorites as a whole. Says Clayton, "The chondrules must have formed early, before the rest of the meteorite picked up its characteristic complement of iron."

Clayton says that the excess oxygen 16 from the supernova probably existed in dust particles that were immersed in the gas cloud that condensed to form the solar system. After the dust melted — by a still unknown process — it solidified into chondrules, but not before it traded its oxygen to varying degrees with oxygen of more normal isotopic ratios from the surrounding proto-solar gas. Clayton says this explains the variations of oxygen 16 found in different chondrules.

After the rest of the meteorite accreted with the chondrules, "there must have been a whole series of reactions involving oxygen, carbon, and iron, and even a little blast furnace-style chemistry with carbon and iron," says Clayton. "It seems that making meteorites involves more steps than had been thought."

Clayton adds that if supernova-produced oxygen 16 was common in the forming solar system, aluminum 26 should have been also. Because it is radioactive, aluminum 26 produces enough heat to have melted any objects in the early solar system that were more than a kilometer across — and even the smallest known asteroids are much larger than that.

"Samples of meteorite that might contain signs of aluminum 26 are difficult to find and even more difficult to measure," says Clayton, "but we're looking."

Radio Telescope for CTIO

A new radio telescope will be established soon at the Cerro Tololo Inter-American Observatory (CTIO) in Chile to survey vast clouds of molecules in previously unexplored areas of our Milky Way Galaxy and the Magellanic Clouds, our nearest galactic neighbors.

The telescope will be used in a pilot program to survey the southern skies with the expectation that larger, more powerful instruments will provide detailed studies of the features it discovers.

The 1.2 meter telescope will be used to study objects that emit millimeter wavelength radio waves in areas of the sky where virtually no such observations have been made previously. The two Magellanic Clouds provide astronomers with a laboratory to study how stars are formed, because those galaxies have no obvious spiral structure like the one which complicates observations in the Milky Way.

The distribution of molecular clouds is important to a wide range of astrophysical problems, such as how stars are formed, how much molecular matter there is in the universe, and how such clouds are formed and destroyed.

Astronomers Patrick Thaddeus and Richard Cohen of Columbia University will build most of the instrument, which will be a copy of one they constructed and have been operating at that university for more than five years. After the instrument is shipped to Chile, it will be operated 24 hours a day by scientists from Columbia, the Goddard Institute for Space Studies and the University of Chile. The new instrument will be housed in an existing building at CTIO, located about 60 miles east of the seacoast town of La Serena.

Probing Beyond the Galaxy

On January 19, 1981, fifty eminent astronomers from England, France, Italy, Australia and South Africa began arriving at Tucson's Kitt Peak National Observatory for a workshop on the physics of active galactic nuclei. Dr. David De Young, staff astronomer at Kitt Peak and a leading researcher in extragalactic astronomy, spearheaded the international effort.

According to Dr. De Young, the purpose of the workshop was to "pursue an extensive and intensive examination of the most violent and energetic events seen in the universe." These events occur in the centers of distant galaxies, some of which resemble the Milky Way.

While our Galaxy contains about 100 billion stars, other active galaxies may contain ten or a hundred times this much material. Seen at incredible distances of over 100 million light-years, these events appear to be gigantic explosions which release energy greater than the combined output of all the stars in our own Milky Way.

The explosions, emanating from the galactic cores, produce X-rays, ultraviolet, visible, and infrared light, and copious amounts of radio waves. By observing the explosions at all of these different wavelengths, astronomers hope to determine just what causes these cosmic outbursts.

The workshop provided an ideal opportunity for guest astronomers from countries throughout the world to compare observations and attempt a resolution of outstanding questions. While the detailed mechanisms which produce these gigantic explosions are still unknown, it is generally thought that they arise at the end of the evolution of very dense clusters of stars. This evolution may result in collisions between the stars themselves, the formation of very massive, short-lived stars, and the eventual development of one or more gigantic black holes. These objects could then be the ultimate engine which supplies the energy for the outbursts seen by astronomers.

Galileo Heatshield Tested

Projectiles fired at speeds of 11,000 mph in an Air Force ballistic range are being used to determine heat-resistant qualities of spacecraft heatshield materials for use on NASA's Galileo Entry Probe System — an exploratory space mission designed to investigate the atmosphere of Jupiter.

NASA now plans to launch the probe in 1985 from the cargo bay of the Space Shuttle. The journey to Jupiter will take three years, and the 693 lb Galileo Probe will enter the atmosphere at a speed of 115,000 mph. After it jettisons the forebody and afterbody heatshields, the system will descend on its parachute. The probe will then relay data back to Earth — a distance of around 400 million miles. The probe will make atmospheric measurements down to a depth where pressure is approximately 20 Earth atmospheres — a similar pressure would be felt under about 700 feet of water. The descent will take about 60 minutes.

The first of eight ballistics range shots of a projectile representing the Galileo Probe vehicle has been conducted in the 1,000 foot long hyperballistics range G at the USAF's Arnold Engineering Development Center, Tullahoma, Tennessee.

The 2-inch diameter 45-degree-angle nosecone is covered with a carbon/phenolic heat-resistant material, designed and fabricated by General Electric Company, to protect the spacecraft's delicate instrumentation during its entry into the harsh atmosphere of Jupiter.

The projectile was fired downrange — propelled by a two-stage gas gun launcher — at about 11,000 mph, and generated peak surface temperatures of about 6,000° F. X-ray and pulsed laser photography was used extensively during the projectile's split-second journey downrange. Open shutter cameras were used to capture pulsed-laser lighted images of the projectile in flight in 20-billionths of a second, allowing test crews and engineers to determine how much heatshield mass was eroded from the test material by ablation or aerodynamic heating and fragmentation.

The projectile traveled downrange on a special four-rail track which guided the model through the test chamber and into a pressurized recovery tube which decelerated the model. After passing through the recovery tube, the model entered a tapered rail section and was slowed to a stop by friction.

Engineers then were able to examine the recovered projectile and determine precisely how much heatshield mass was lost due to aerothermodynamic erosion. This will help NASA decide on the required thickness of material to protect the probe spacecraft when it enters Jupiter's atmosphere.

The Galileo Probe program is being managed by NASA's Ames Research Center at Moffett Field, California, and the spacecraft is being built by Hughes Aircraft. The heatshield will be provided by General Electric under a subcontract.

Keep magazines, catalogues, journals
NEAT AND ORGANIZED
in home, office, workshop!

End Clutter! Find it fast —
the first time with handy, husky,
heavy duty fiberboard

SHELF FILES

Eliminate the mess of loose magazines, catalogs and newspapers. Find what you want when you want it by using these handy shelf or desk top files. Adhesive ID labels included.

6 POPULAR SIZES AVAILABLE

From digest size to newspaper size! Popular letter and magazine size (9" x 11½", 3¾" box width) — 8 for $13.59. 25 for $31.95 prepaid. Sturdy, heavy-duty fiberboard will last for years! Charge it! Call or mail coupon today.

Professional Aids Co., Suite A371
3685 Commercial Ave., Northbrook, IL 60062 312/291-0558

Please rush postpaid Fiberboard Desk and Shelf Files as checked below:

How Many	Qty.	Size	Price	Total Price
	8	Letter Size	$13.59	
	25	Letter Size	$31.95	

☐Check for Free Catalog

I enclose $_____ full payment. Ship postpaid.

☐ Charge it to ☐ Visa ☐ Mastercharge TOTAL: __________

Acct. No. __________ Exp. Date ________

Name __________

Address __________

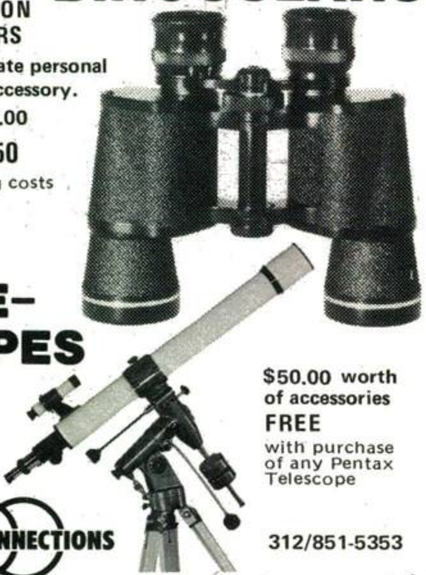
City/State/Zip __________

Illinois Residents add 6% Sales Tax, please. Other sizes from digest to newspaper available.

DEALER FOR: MEADE · PENTAX · LEO HENZL FILTERS · DYNAMAX · TELE VUE · CLAVE EYEPIECES · UNIVERSITY OPTICS · FUJINON · ABRAXAS ELECTRIC

PENTAX
BINOCULARS

7x50 ZCF
NIGHT VISION
BINOCULARS
. . .the ultimate personal star gazing accessory.
regular $118.00
NOW $99.50
plus shipping costs



and
TELE-
SCOPES

$50.00 worth of accessories
FREE
with purchase of any Pentax Telescope

COSMIC CONNECTIONS
312/851-5353
1460 N. Farnsworth Aurora, Illinois 60505

STAR TRACKER

At the Star Tracker we feel that comparison between brands is essential to get the best equipment for your purposes. We keep a variety of telescopes in stock, allowing you to test each instruments performance.

If you are unable to visit us then write for our catalogue. In addition to numerous telescopes and accessories, our catalogue includes; an explanation of eyepiece optics, telescope selection guides and optical maintenance procedures. The extent of equipment we keep in stock allows us to ship to you promptly.

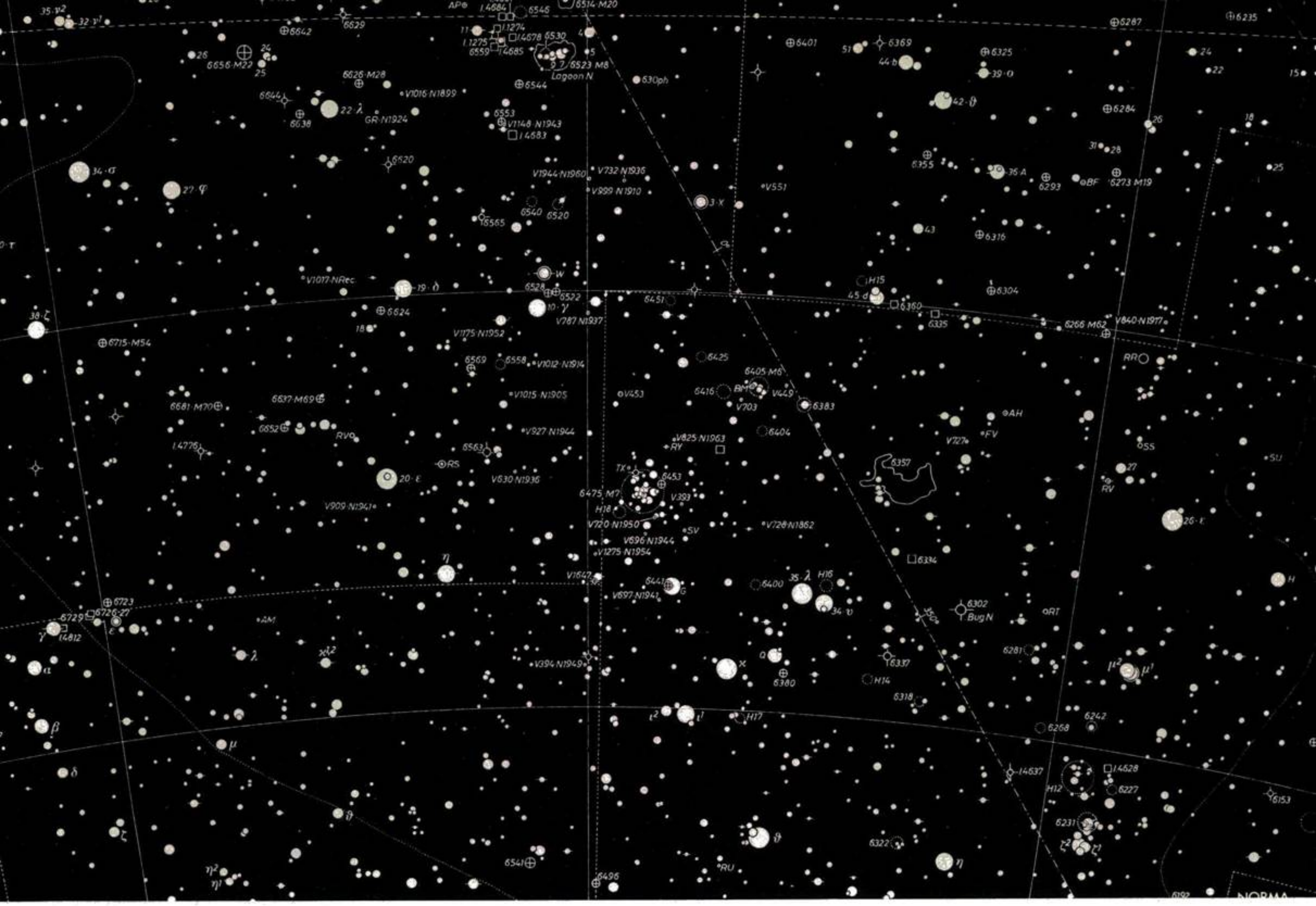
Send $2.00 for your catalogue today!
(Allow 4-6 weeks for delivery)

Visa
MasterCard

STAR TRACKER

3093 Walnut St. Dept. AS-6, Boulder, CO. 80301 (303) 442-6805

CELESTRON•QUANTUM•EDMUND•QUESTAR•MEADE•STAR•UNITRON•PENTAX



It's here!

SKY ATLAS 2000.0 by Wil Tirion

Step into the 21st century with the first major new generation star atlas for epoch 2000. Sky Publishing Corp., long the world's leading producer and supplier of all types of celestial charts and observing aids, is proud to present this magnificent work, which was planned with both the professional and amateur observer in mind. Its 26 charts contain some 43,000 stars to visual magnitude 8.0, plus 2,500 deep-sky objects.

Above is a section of chart 22, at 90 percent published size, which, unlike other leading star atlases, includes the splendid Scorpius-Sagittarius area on one chart — truly a deep-sky treasure trove of clusters and nebulae. Also unlike previous atlases, many of these objects are labeled with their popular names (such as the Lagoon and Trifid nebulae) for the convenience of observers.

Sky Atlas 2000.0 has many special features, such as four insets which show in detail the Pleiades, Orion Nebula, and fields of Barnard's star and Proxima Centauri. (What other atlas identifies and helps you locate these well-known stars?)

Another area in which the Tirion atlas is unsurpassed is its use of carefully chosen map projections that produce virtually unnoticeable distortion of star patterns — you see the constellations just the way they are in the sky, which is of real help to the novice.

To be among those who obtain what will surely be a collector's item — the historic first printing — order *now* and avoid delay and disappointment. The demand will be heavy!

Sky Atlas 2000.0 is available in two editions: Desk (black stars on white background) and Field (white stars; illustrated above). Both are printed on heavy, stiff paper. The 27 13½-by-18½-inch sheets (26 charts plus introduction) are shipped flat.

Order 4631X	*DESK TIRION*	**$14.95**
Order 46328	*FIELD TIRION*	**$14.95**

Special! Two sets of either edition or one of each.

Order C0011	*TIRION PAIR*	**$24.95**

Mass. residents add 5% tax.
Foreign add 10% for postage.

SKY PUBLISHING CORPORATION
49-49 Bay State Rd. • Cambridge, Mass. 02238

ASTRONOMY
REVIEWS

Majestic Lights
Robert H. Eather
323 pages, hardcover, $49
American Geophysical Union (1980)

This book is lavishly illustrated with color photographs of auroral forms and black and white sketches used as background for Eather's historical romp through man's awareness of auroral activity.

"Romp" may sound a little flippant, but in spite of all the work Eather has put into gathering historical material on aurorae, he suffers from "von Danikenism." This debilitating disease sometimes afflicts people doing historical research. Its main symptom is a tendency to see proof of an impassioned thesis under every stone — even where none exists.

Eather attempts to prove aurorae were visible to ancient peoples living at low geomagnetic latitudes — people who, inspired by these rare, heavenly spectacles, recorded the experiences in their literature. This is a fine thesis, but he tends to get carried away looking for evidence.

Early in the book, the author suggests that a passage from the Bible written around 2000 B.C. is the oldest such literary record. The verse refers to the ritual of covenant entered into by Abraham and God that required both parties to walk between the severed bodies of sacrificial animals. It reads: "Behold a smoking furnace and a burning lamp that passed between those pieces." (Genesis 15:17)

"The smoking furnace and burning lamp represent God walking between the divided animals to seal his promise in a way Abraham would readily understand," states Eather. "If this oldest of stories of the Old Testament has any factual basis, it implies a heavenly illumination, described in some translations as a fiery torch passing across the night sky."

All right, I can buy that. But then Eather concludes, "Might this be the oldest written account of an aurora?" The much more likely possibility of a meteor or bolide is not even mentioned.

In another example a few pages later, Eather suggests the crescent symbol on the Turkish flag was inspired by an auroral arch. According to legend, when Philip of Macedon attempted a nighttime raid on the city of Byzantium in 339 B.C., the raiders were revealed to the city's inhabitants by the light of the cresent moon. Eather postulates it was a bright auroral arch, fortuitously timed to illuminate the successful defense of the city. In commemoration, according to Eather, the Byzantines incorporated the crescent on their flag. Later, in 1453, it was adopted by the Moslems when the Ottoman Turks finally succeeded in capturing Byzantium (Constantinople).

But there's one catch to this charming tale. Turkish Moslems had already been using the crescent symbol on their flags more than a hundred years before 1453. In fact, the crescent moon (with or without an accompanying star) was a very popular sacred motif in the Near East and was already evident in artwork of the 3rd millennium B.C.

Unfortunately, it seems Eather researched the legendary roots of the Turkish flag's crescent, not the historical.

Beyond the speculative region of ancient history, Eather's account of the development of auroral science improves immensely. He also includes chapters on aurorae in poetry and other literary forms, and do-it-yourself auroral photography. No doubt his intimate familiarity with the subject comes from the extensive research he has done around the world, both poles included.

In Eather's own words, "Auroral science has probably progressed more in the past 20 years than in the previous 2000." How true. His book came off the press only months ago and already his treatment of some topics could be updated.

Research recently published by Colin S. L. Keay in the *Journal of the Royal Astronomical Society of Canada*, and *Science* convincingly argues that humans can perceive very low frequency radio waves emitted by aurorae — an explanation of reported auroral noise Eather rejects outright in favor of a brush discharge mechanism caused by aurorally induced electric fields at ground level. Eather's use of the same mechanism to explain rare reports of auroral odors is interesting, however. Perhaps a combination of both aurorally induced radio waves and ground level electrical discharges is responsible.

Eather also credits the occurrence of "earthquake lights," often mistaken for aurorae, to the glow of power lines ruptured during quakes. But, this doesn't explain why these lights are seen immediately prior to quakes as well.

Majestic Lights is more than a glamorous coffee table book. The answer to just about any question you care to ask about aurorae is contained between its covers. Eather is to be commended on a well-done and thorough job. *Celeste Peters.*

Strategies for the Search for Life in the Universe
Michael D. Papagiannis, ed.
253 pages, paperback, no price avail.
D. Reidel Publishing (1981)

It's unlikely that any other field of science mines its data quite as deeply as SETI does. But what's to be done? It's a subject without a subject — so far. This book is a record of a joint session of several IAU commissions held at the union's meeting in Montreal, August

1979.

The papers were grouped into four main topics: 1) N — is it big, small, or in between? (aficionados will instantly recognize "Drake's Number"); 2) strategies for searching by radio; 3) strategies to look for planets around other stars (including some very interesting possibilities with the Space Telescope); and 4) how does an advanced civilization betray its presence?

Out of the Darkness: the planet Pluto
Clyde W. Tombaugh and Patrick Moore
221 pages, hardcover, $14.95
Stackpole Books (1980)

Who could better tell the tale of the discovery of Pluto, the ninth planet of the solar system, than this team: one of today's best popularizers of astronomy, and the man who actually discovered the planet 50 years ago?

Patrick Moore, a well-known astronomical writer, and Clyde Tombaugh, discoverer of Pluto, have written a fine book on this momentous discovery. Rather than anonymously laying claim to all sixteen chapters, the two have taken the unusual step of clearly identifying which chapter each wrote. With characteristic clarity, Moore writes the chapters on the nature of the solar system (chapter 2), the discoveries of Uranus and Neptune (chapters 3 and 5), the puzzle of "Bode's Law" and the asteroids' discovery (chapter 4), and what's currently known about Pluto (chapter 15).

The rest of the book is written by Tombaugh — after all, it's his story: the story of a 24-year-old amateur astronomer who discovered a planet.

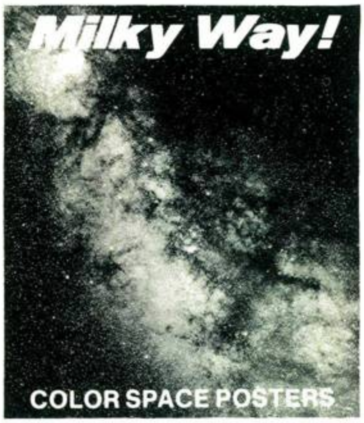
Even more, he did it without high-speed computers, vidicon tubes, charge-coupled-devices, and all the other accouterments of modern astronomy. He did it with a telescope, photographic plates, a "blink comparator," and his naked eye — plus enormous amounts of patience and persistence. Between April 1929 and February 18, 1930, Tombaugh visually examined the images of nearly 2,000,000 stars in his search for "planet X."

Tombaugh's tale is simply told. His prose limps at times, but it generally strides along in a firm and confident fashion, as he himself must have done while working in the fields of his family's farm near Burdett, Kansas. As a youngster, in his spare time, he taught himself to build telescopes and observe the stars and planets. He knew, he writes, that he had little chance of getting a college education. But he wanted desperately to become an astronomer, so he sent several of his drawings of Jupiter and Saturn to Lowell Observatory in Arizona, hoping to get at least some kind of job.

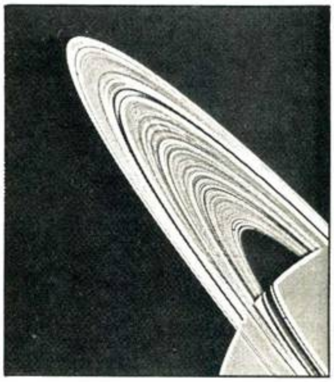
The astronomers at Lowell — C.O. Lampland and the brothers V. M. and E. C. Slipher — hired him because the observatory budget was so meager they could only afford an amateur.

Tombaugh relates clearly the drama of the actual discovery of Pluto: his instant realization, "That's it!" and the reaction of Lampland ("'I heard the clicking of the comparator suddenly stop, then a long silence.' He [Lampland] suspected I had run into something unusual."), his attempt to be elaborately casual as he strolled into V. M. Slipher's office to announce the discovery, and the interesting bit of trivia that after discovering Pluto, he went to see a movie — *The Virginian* — starring Gary Cooper. The author also recounts, with the earnestness of a dedicated telescope-maker, the idiosyncrasies of the 13-inch telescope used in the Pluto search.

Tombaugh gives the story of naming the planet a special treatment. The suggestions, included "Zeus," "Lowell," and "Constance" — the first name of the late Percival Lowell's widow. (She suggested it herself.) The



STAR CLOUDS & DUST IN THE MILKY WAY
Enjoy the most spectacular space photographs taken by the giant telescopes of Kitt Peak and Cerro Tololo Observatories. These full-color posters measure 18½" x 22¾", are suitable for framing, & are mailed rolled.
Any 3 posters $6.50 ppd.
All 6 posters $12.00 ppd.
CHECK POSTERS WANTED:
☐ **PS06 Total Solar Eclipse**
☐ **PS08 Eagle Nebula**
☐ **PS010 Ring Nebula**
☐ **PS011 Eta Carinae Nebula**
☐ **PS013 Milky Way Star Clouds**
☐ **PS014 Lagoon Nebula**
☐ Enclosed is $1.00 for complete astronomical catalogs
FOREIGN ORDERS ADD $2.00 FOR POSTAGE
Send check or money order to:
DEPT. A
Hansen Planetarium
15 South State Street
Salt Lake City, Utah 84111


NASA PHOTOS

SPECTACULAR RESULTS FROM NASA!
JUST RELEASED! SPACE SHUTTLE/VOYAGER – SATURN
-SPACE SHUTTLE SLIDE SETS-
20 SLIDE SET — $12.95
40 SLIDE SET (Including Narrative Cassette) — $16.95
POSTAGE AND HANDLING FOR EACH ABOVE SET — $2.50
-SPACE SHUTTLE PHOTOGRAPHS-
High Quality Prints
SET OF TWO, 8x10 — $6.00 SET OF TWO, 16x20 — $16.00
POSTAGE AND HANDLING FOR EACH 8x10 SET — $3.00; 16x20 SET — $5.00
-VOYAGER – SATURN SLIDE SET-
20 SLIDES (With Photo Analysis Report) — $12.95
SPECIAL OFFER! -VOYAGER – SATURN POSTER SET-
TWO 11x17 COLOR POSTERS — $5.00
POSTAGE AND HANDLING FOR EACH SLIDE OR POSTER SET — $2.50
NEW! SPACE CATALOG – .75¢
CALIFORNIA RESIDENTS ADD 6% TAX
FOREIGN ORDERS ADD AN ADDITIONAL $2.00
ALLOW 3 WEEKS FOR DELIVERY
POSTAGE AND HANDLING MUST ACCOMPANY ORDER
·SPACE GRAPHICS·
P.O. BOX 764, DEPT. A CHATSWORTH, CALIF. 91311 (213) 341-4216

DEEP-SKY BINOCULARS

Our popular 80mm binoculars now feature an improved, strong, one-piece construction. Fully coated optics. Erfle eyepieces on 20X units, Kellner type on 11X. Center focus design with a reinforcing bridge between objectives. Certificate of collimation with every pair. Complete with straps, dust caps, and carrying case.

11X80 or 20X80	**$179.95 ppd.**

1¼" ASTRONOMICAL EYEPIECES

Plössls. The excellent Plössl lenses at big savings. **6mm, 9mm, 12.5mm, 18mm, 25mm, 40mm**	**$45.00 each ppd.**
Set of any 5	**$210.00 ppd.**
8.4–2.1mm Zoom	**$49.95 ppd.**
Kellners. 3-element. **9mm, 12mm, 20mm, each**	**$14.95 ppd.**
Königs. The leader in widefield eyepieces. **8mm, 12mm, 16mm, 24mm**	**Each $39.95 ppd.**
32mm König	**$44.50 ppd.**

Binocular Eyepiece holder	**$269.95 ppd.**
Porro prism	**$29.95 ppd.**
Illuminated Reticle. 12.5mm OR with battery pack and etched glass reticle	**$46.95 ppd.**

2" O.D. OCULARS

32mm Erfle	**$69.95 ppd.**
32mm König	**$84.95 ppd.**
55mm Plössl	**$79.50 ppd.**

VIEWFINDERS

8x50 right angle with bracket for C-8 and Meade 2080 Cross Hair	**$54.95 ppd.**
With special True Polaris North reticle	**$57.95 ppd.**
With illuminated cross hair	**$76.95 ppd.**

REFLECTOR PARTS

Universal focusing mount. For scopes up to 17"	**$21.75 ppd.**
Vega 2. For 2" eyepieces	**$42.95 ppd.**
6" Expandable mirror cell	**$14.95 ppd.**
8" Expandable mirror cell	**$16.95 ppd.**

ACCESSORIES FOR CELESTRON AND MEADE SERIES 1000 & 2000.

AC/DC Dual-axis drive corrector. Joy stick with Dec. motor and bracket. (for C-8 and C-5 only)	**$187.00 ppd.**
Telextender	**$15.95 ppd.**
Camera adapter	**$15.95 ppd.**
Telecompressor (30 mm size)	**$40.95 ppd.**
Telecompressor (50mm size)	**$75.95 ppd.**
Off-axis guider with 12.5 mm OR illuminated eyepiece	**$85.95 ppd.**
Deep-sky f/5 visual adapter	**$79.95 ppd.**

POPULAR ASTRONOMICAL ITEMS

ACCUSTAR	**$13.95 ppd.**
Celestron Meets the Home Video Recorder Our popular book that introduces the amateur to video astronomy	**$6.95 ppd.**
Exposure Dial. For Celestron 8, Meade 2080, and Dynamax 8. Get better pictures. Don't guess at exposure times	**$8.95 ppd.**

CALL TOLL FREE FOR FAST SERVICE

(800) 521–2828

•FREE CATALOGUE•

UNIVERSITY OPTICS INC.
P.O. Box 1205-A 2122 E. Delhi Rd.
Ann Arbor, Michigan 48106

VISA **MASTERCARD**

first non-astronomer to suggest "Pluto" was a Miss Venetia Burney of Oxford, England. Age eleven!

The whole book is a delightful look back at the discovery of the ninth planet.

The illustrations in *Out of the Darkness: the planet Pluto* are sometimes confusing and difficult to understand, and the use of English and metric measurement side-by-side (metric in parentheses) makes the pace of the story uneven.

But these are minor faults. The book is an excellent "read" — a dramatic retelling of the discovery of Pluto by the only human alive today who discovered a planet. *Joel Davis*

The History of the Telescope

Henry C. King
456 pages, paperback, $8.95
Dover Publications (1979)

While playing in spectacle-maker Hans Lippershey's shop in Middleburg, Holland, one sunny afternoon in 1608, two inquisitive children noticed the weathervane atop a nearby church appeared to be much larger than normal when viewed through two precisely aligned lenses.

Intrigued by the discovery, Lippershey mounted the lenses in a tube. Like the children, he was enchanted with the result. Thanks to his young cohorts, he became the first human to peer through the instrument known later as the telescope.

News of Lippershey's marvelous toy reached Galileo Galilei within a year. On a crisp January evening, he pointed his own just-completed *perspicillum* (as he called it) at the sky. In those few magnificent moments, modern astronomy was born.

Galileo noted several small stars near the disk of Jupiter and the following evening found — to his astonishment — that the "stars" had shifted their location relative to the planet and one another. By early spring, he knew with certainty that these four moving stars were satellites orbiting Jupiter.

Fame followed Galileo. In 1611, at a banquet in Rome in his honor, a new word to replace *perspicillum* was coined by poet Johann Demissiani. That word was telescope.

King's *History of the Telescope* is the pre-eminent work describing the development of this world-altering, mind-expanding invention. The Dover volume (reprinted from the original 1955 edition) contains hundreds of references. Many of the 196 illustrations are photographs; other graphics include line drawings, diagrams, and engravings.

This superb treatise on the telescope is a painstakingly, almost pedantically researched volume that is the definitive work on the growth and refinement of the instrument. The scope of the book is wide, spanning from pre-telescopic observations made in the time of Plato and Aristotle, up to the maturation of radio astronomy in the early 1950s.

King includes an abundance of information about the craftsmen themselves. Although the instrument makers figure more prominently than the users, King places the pioneer observers in convenient historical perspective.

Even in its completeness and attention to detail, the volume radiates a warmth and human quality which transcends many historical works. The generous use of primary source material adds greatly to this human side.

For example, the scarcity of flint glass in the early 1800s was referred to in the obituary notice of telescope-maker Charles Tulley. In part, the notice read, "It is grieviously to be lamented that much of the labour of this invaluable artist was absolutely wasted, from the impossibility of procuring flint glass capable of forming an object-glass at all; lens after lens having been rejected by him."

Many modern amateur astronomers have found themselves in awkward predicaments arising from nocturnal observing sessions. Those who have awakened suspicion on the part of neighbors or who may have encountered skeptical law officers, might feel a kinship with nineteenth-century telescope-maker and observer James Nasmyth.

According to King, Nasmyth often observed from his small garden near a well-used waterway. Sometimes clad only in his nightshirt, Nasmyth was once seen by a passing boatman who was responsible for the widely believed story that a ghost could be seen in Nasmyth's garden, moving among the trees with a coffin in its arms!

King suggests that stargazing in the past was less a gentle pursuit than it is today. Many early observers suffered various injuries in tumbles from their lofty perches high on an ungainly telescope mount. Sir William Herschel's astronomer sister, Caroline, once had an extremely serious accident when she fell on a large hook covered by snow. An astute observer of both the heavens and the human condition, she wrote, while recuperating, "I could have a pretty long list of accidents which were near proving fatal to my brother as well as myself."

James Lick, the California millionaire who funded the observtory *bearing his name, has a unique final* resting place. Mr. Lick's earthly remains, according to King, are stowed within the brick pier which supports the mount of the Lick 36-inch refractor, which unfortunately did not see first light before Lick's death.

E. E. Barnard was another American observer who physically gave of himself in his devotion to observational astronomy. Working one bitter winter night at Yerkes Observatory in Wisconsin, Barnard found to his pain and dismay that the skin of his nose had frozen to the rim of the eyepiece he was using. When he pulled away from the massive refractor, Barnard left some nose skin attached to the instrument.

Many early observers, in their zeal to examine the Sun, suffered varying degrees of damage to their eyes. After lengthy observation of the Sun in an attempt to measure its diameter, John Greaves, professor of astronomy at Oxford, said, "... for some days after, to that eye, with which I observed, there appeared, as it were, a company of crows flying together at a good distance." Luckily, the professor's vision was not permanently damaged and normal, bird-free eyesight returned some days later.

King notes the remarkable optical qualities of certain liquids — hydrochloric acid and carbon bisulfide, for instance — which led to their use in objective lenses. Indeed, the Reverend T. W. Webb (author of *Celestial Objects for Common Telescopes*) used a fluid lens telescope on occasion.

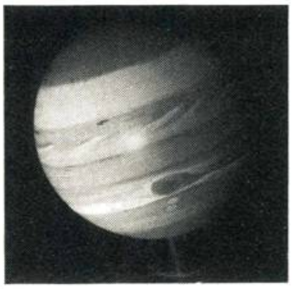
King's splendid account of the invention which has had an immeasurable impact on the inhabitants of this planet is a singular work. *The History of the Telescope* should be read by anyone who professes an interest in astronomy. *Gail O. Clark.*

The Yachtsman's Guide to Celestial Navigation
Stafford Campbell
120 pages, hardcover, $8.95
Ziff-Davis (1979)

The bias here lies on "classical" (sextant) navigation, as opposed to the "black-box" (or calculator) variety. Yet unlike many introductory works on navigation, which often read like a text for midshipmen at Annapolis, Mr. Campbell's book keeps it simple. Step by step, he shows how to take a Sun sight and reduce it to give a position line, the one observation most useful to amateur navigators.

The candid admission that impeccable accuracy is not easily achieved or even generally necessary to most small boat skippers is a key point of this book. Accordingly, it provides a basic, but adequate, set of instructions.

JUPITER as seen by Voyager I & II
Full Color Globes. 20cm diam. $35.00, 28cm $50.00



Send check or postal money order to:
KEPLER PROJECT
OBSERVATIONAL RESEARCH CENTRE
P.O. BOX 03565 • HIGHLAND PARK
DETROIT, MI 48203 • USA 313-865-3084
Postage incl. in price.

ASTRONOMY
NEW ENGLAND
Call us first for
Celestron, Meade, and Edmund Telescopes!

- ★ Visit our brand-new spacious store, open for enjoyable browsing.
- ★ Telescopes, books, and unusual astronomy products on display and in stock. Used telescopes *in stock.*
- ★ Telescope trade-ins accepted.

Call for latest store hours: (617) 429-1712
SEND $3 FOR OUR UNIVERSE CATALOG!
215 Highland St.
Holliston, MA 01746
(617) 429-1172 Call Anytime!

Tele Vue™

FOR THE ULTIMATE IN YOUR TELESCOPE'S PERFORMANCE!

TELE VUE 7.4mm PLÖSSL
TELE VUE 10.4mm PLÖSSL
TELE VUE 17mm PLÖSSL
TELE VUE 26mm PLÖSSL

7.4-mm 10.4-mm 17-mm 26-mm

Plössl
EYEPIECES

$55. EA. PPD. (U.S.A.)

NEW DESIGN FEATURES EXCEPTIONAL PERFORMANCE AND VALUE:

- **FOUR-ELEMENT PLÖSSL TYPE**
  - for razor sharp images, full color correction
- **WIDE 50° FIELD**
  - larger than orthos, sharp to edge, ideal for RFT's
- **MULTI-COATED**
  - for maximum contrast and brilliance
- **PARFOCAL**
  - for viewing convenience
- **THREADED BARRELS**
  - for Nebula and other filters
- **ASTROPHOTOGRAPHY**
  - ideal design for eyepiece projection
- **SUPERIOR CONSTRUCTION**
  - chromed brass 1¼" barrels, blackened lens edges
- **7.4mm 10.4mm 17mm 26mm EFL**
  - observer-chosen focal length range

YOUR SATISFACTION IS GUARANTEED, OF COURSE.

The following unsolicited letter is from a nuclear engineer who owns 6 makes of eyepieces and a Celestron 8.

Dear Mr. Nagler,

This last day of 1980 is the first day of a whole new era of enjoyment of my telescope for me – thanks to your new Plössl eyepieces.

Last night I got my first chance to compare your TELE VUE Plössls (26mm, 17mm, and 10.4mm) to my XXXX and XXXX. I found the TELE VUE eyepieces to be superior in every respect: wider and flatter field, sharper star images to the edge, better eye relief, and vastly higher contrast. This last item really surprised me. The night was murky with wood smoke particulates from the suburbs as well as with the usual haze and pollution common to the Washington, D.C. area – not really a good night at all – but around here, "ya takes what ya gets". For an hour, I compared your 26mm Plössl to my 24mm XXXX. I had always considered the XXXX unbeatable for sharpness and image contrast, but the TELE VUE was far better! For example, on M42, more outer wreath nebulosity stood out against the (bright) sky background than with the XXX plus a nebula filter! In the trapezium group, two of the dim field stars (stars E and F in Mallas and Kreimer, the Messier Album, P. 99) were easily seen using the TELE VUE eyepiece but were invisible through the XXX even though its slightly shorter f.1. should have made them even easier to see. This observation was confirmed by another person working with me.

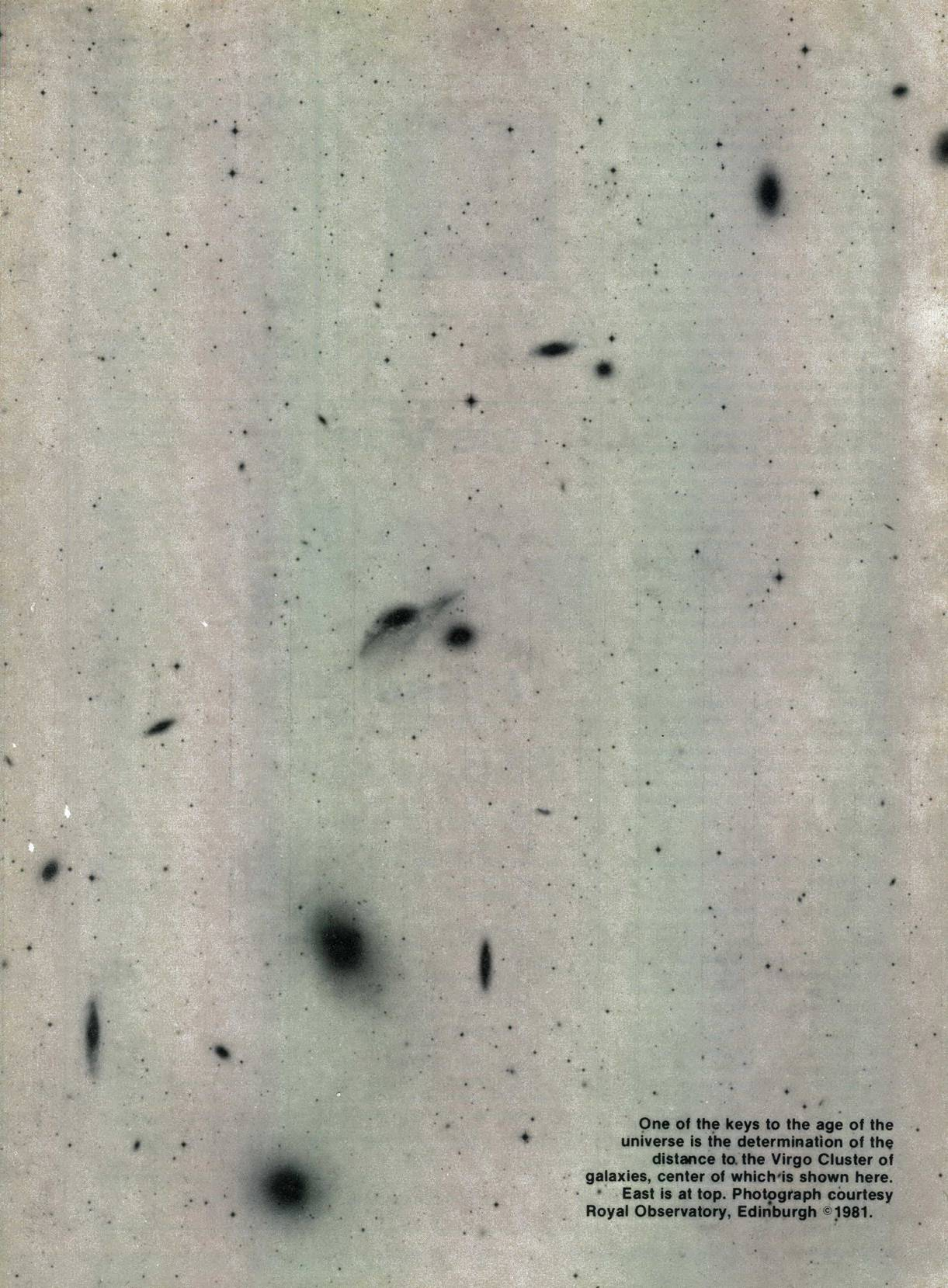
As you can see from the attached list of eyepieces that I have owned over the last 5 years and now own, I have rejected more than I've kept (this includes one 2-inch $200 eyepiece that many experts had said was the very best available). I can tell you with assurance that my new TELE VUE Plössls will never appear on my list of rejected eyepieces!

You have my admiration and sincerely felt thanks for bringing such quality to the American amateur astronomer.

Yours most sincerely,

Pat Walker
Springfield, VA

TELE VUE OPTICS, INC.
15-A GREEN HILL LANE, SPRING VALLEY, NY 10977
PH. 914-354-4262



One of the keys to the age of the universe is the determination of the distance to the Virgo Cluster of galaxies, center of which is shown here. East is at top. Photograph courtesy Royal Observatory, Edinburgh ©1981.

the Age of the Universe

by Barry Parker

"How old is the universe?" is a question that has intrigued mankind for ages. The Babylonians made an estimate of the answer 4000 years ago. But they knew almost nothing about the structure and evolution of our universe so their estimate was only a guess. With the emergence of Christianity, the question took on a new importance, so scholars began searching the scriptures for clues. By the sixteenth century, they thought they had the answer. Archbishop James Ussher announced that he had traced scriptural dates back to "the beginning," and on the basis of his study, proclaimed that the world had been created on a Sunday morning in the year 4004 B.C. For many years, this date was gospel.

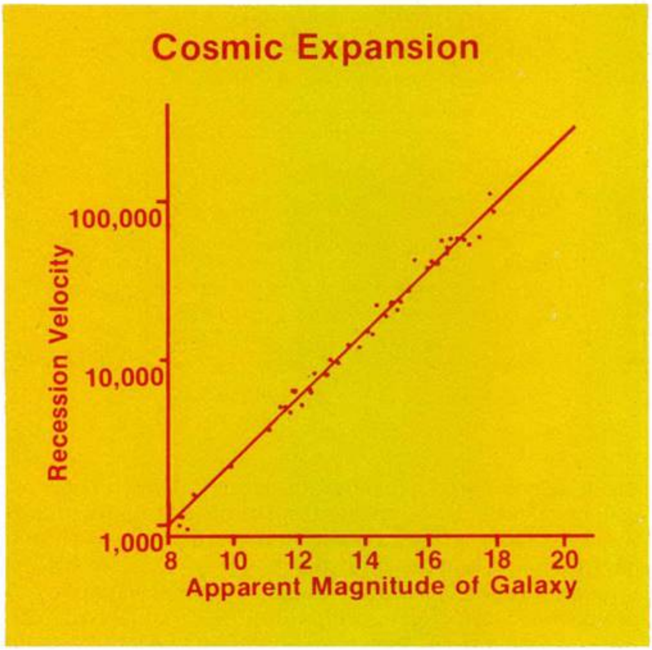
Not everyone agreed with Archbishop Ussher. In 1749, the French naturalist Georges Buffon published a paper showing that the Earth must be at least 70,000 years old. Then, in 1755, the German philosopher Immanuel Kant went even further — he stated that the Earth could be millions of years old. To many this was a shocking statement, but it no doubt caused them to wonder. Was it possible? Could the Earth actually be that old? Eventually it became obvious that the history of the Earth could not be fitted into a time span of only a few thousand years — and the universe was certainly much older than the Earth. As more reliable techniques were developed and better and better data became available, the estimated age of the universe steadily increased and has continued to increase until quite recently.

What, in fact, do we mean by "the age of the universe"? To answer this we must turn to the most generally accepted model of the origin of the universe: the Big Bang. According to this theory, the universe began as a fiery explosion that filled all space — each particle of matter rushing away from its companion particles at speeds close to that of light. For the first million years or so, the matter was uniformly distributed, but eventually clumps formed and gradually evolved into galaxies. Today we live in one of these galaxies and we find that galaxies are still moving away from each other — except when they are bound together in clusters. The "age" we are referring to is the time that has elapsed since this primeval explosion.

It is easy to see that the age of the universe is related to its size: the older it is, the more time it has had to expand, and thus the larger it is. We also realize that as we look out into space we are actually looking back in time, because the light from the objects we see here takes many years to reach our eyes. When we look at a distant galaxy, for example, we see that galaxy not as it is now but as it once was, millions of years ago. You might think that if we could "see" to the edge of the universe, we would be able to "see" the Big Bang explosion itself. We can — and what we "see," or rather hear, with our radio telescopes, is *microwave background radiation*, the echo of the Big Bang. (See "The Cooling Fire of Creation," ASTRONOMY, March 1980.)

How can we determine, then, how long ago this explosion took place? If we could calculate the rate of expansion of the universe, and the distance to the galaxies, we could mathematically turn the expansion around and see how long it takes for the galaxies to collapse back on themselves. Think of the expansion occurring in a movie. If you run the movie backward, the galaxies would all appear to move toward one another. To determine the age of the universe, you would have to find out how long you had to run the movie until the galaxies were all back together.

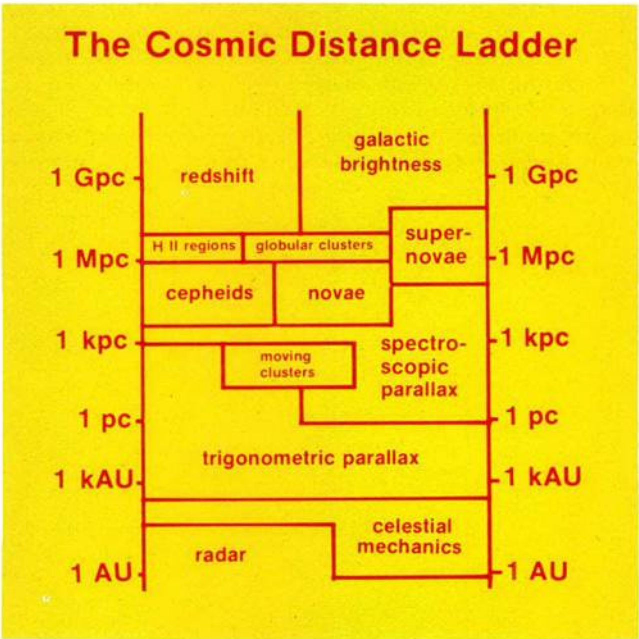
During the 1920s and early 30s, Edwin Hubble set out to do just this. By measuring spectral lines from distant galaxies he determined their *redshift*, in other words, the shift of their spectral lines from their "usual" position, their position if coming from a stationary object. The amount of this shift told him how fast these galaxies were receding from us. For these galaxies, Hubble devised various methods for estimating their distance, and then plotted redshift — or velocity — against distance. He obtained an approximately straight line. The slope of this line gave him an important number — a number we now refer to as the Hubble constant.


Cosmic Expansion

What is the meaning of this constant in the context of our search for the age of the universe? If we knew it exactly, we could merely measure the redshift of a galaxy and we would know its distance from us. But even more important, this constant gives us the age of the universe. If the universe has been expanding uniformly since the Big Bang explosion, the reciprocal of the Hubble constant (1 divided by the constant) gives us the age directly.

But there is considerable evidence that this isn't the case — the expansion appears to be decelerating. If it is, we must allow for it. The actual age of the universe would then be *less* than the reciprocal of the Hubble constant (a number we call the "Hubble age" to distinguish it from the actual age). In short, the Hubble constant gives us the maximum age, or the age if there has been no deceleration.

To determine the age accurately, then, we obviously need two constants: the Hubble constant (H_o) and a number that represents the deceleration (q_o). These two constants play a central role in cosmology. If we knew their values accurately, we would know all there is to know about the large scale structure of the universe.


The Cosmic Distance Ladder

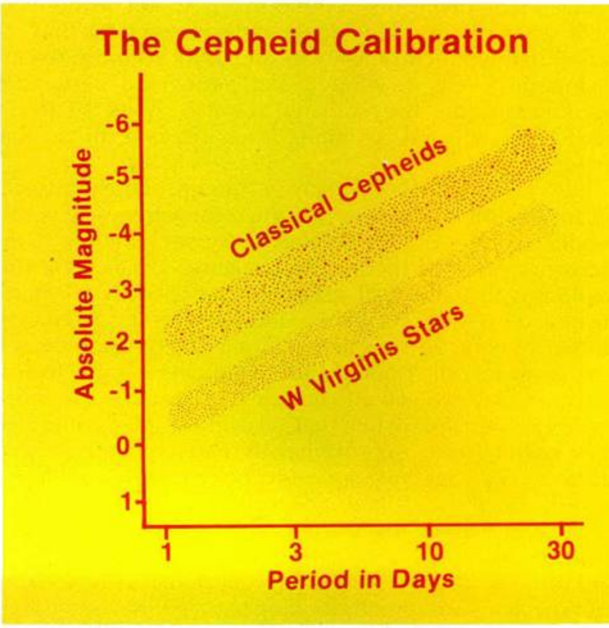
When Hubble decided to determine the ratio between galactic distance and velocity, he needed a method for determining the distances to the galaxies. It soon became obvious that this was not going to be an easy task — it is, in fact, a problem that still plagues us today. Hubble used what he called "distance indicators," sometimes also called "standard candles." To get his standard candle, he assumed that if he could find two stars, one in our Galaxy and one in a distant galaxy that had an identical intrinsic property such as spectra, color, or light curve, then these two stars should have the same luminosity or absolute brightness. As his first standard candle, Hubble chose Cepheid variables. A period-luminosity relationship for these variables had been worked out a few years earlier. Using this relationship Hubble could, with a simple measurement of the period of the variable, determine the luminosity or absolute brightness of the star. Knowing this, he could — with the appropriate calibration of the scale — determine the distance of the star.

Cepheid variables were Hubble's "primary candles." They allowed him to determine the distance to a few relatively nearby galaxies in which stars could be resolved. But Hubble was interested in distant galaxies, so he needed more than this — a large-scale standard candle that could tell him how far away these more distant galaxies were. He chose what he thought was the brightest star in each galaxy and these became his "secondary indicators." Finally, for the very distant galaxies in which no individual stars could be seen, he assumed the brightest galaxy in each cluster of galaxies would be about the same magnitude as the brightest in others. He chose these galaxies as his "tertiary indicators." Then he calibrated each of these candles.

This was Hubble's "distance ladder." It was an ingenious approach, but it had an obvious flaw. Each rung of the ladder depended on the accuracy of the rung below it. It was, in a sense, like a house built of cards — if one of the cards fell, the entire house collapsed. Hubble managed, however, to get a plot of redshift versus distance for a large number of galaxies. This gave him a Hubble constant of 526 kilometers per second per megaparsec. (A megaparsec is 3.26 million light-years.) This corresponded to an age of approximately two billion years. To some, two billion years may have seemed like a long time, but to geologists it was far too short. They had evidence that the Earth was considerably older than this, and of course the universe couldn't be younger than the Earth. Something was obviously wrong.

The difficulty was resolved several years later by Walter Baade of the Mt. Wilson Observatory. During the long dark nights of World War II, Baade began a study of stellar types in nearby galaxies. He noticed that there are two distinct classes of stars, which we now refer to as population I and population II. Population I stars are hot and young, with an abundance of heavy elements, and are generally located in the disk and spiral arms of a galaxy. Population II stars, on the other hand, are old and located primarily in the nuclear bulge and halo galaxies. They have few, if any, heavy elements. When he looked at the variables Hubble had used, Baade noticed that some of them were population I, while others were population II. This meant there were two quite similar types of variables: classical Cepheids and what we now call W Virginis variables (after the brightest one in the group) — and these two types obeyed different period-luminosity relations. Hubble had not known this. Recalibrating the cosmic distance scale decreased Hubble's constant by a factor of two, and thus doubled the age of the universe.

Another decrease in the constant came a few years later. Allan Sandage of Hale Observatories discovered that the bright "stars" in the distant galaxies Hubble had used as standard candles were not single stars. They were actually star clusters and their associated nebulosity. As a result the Hubble constant was decreased again, this time dropping to approximately 100 km/sec/Mpc, corresponding to an age of about ten billion years. Throughout the 60s, it remained at this value. In the late 60s, however, Sandage and Gustav A. Tammann of Basel, Switzerland decided to take a more


The Cepheid Calibration

careful look at Hubble's observations. Following basically the same route — using Cepheid variables as primary indicators, bright stars as secondary indicators, and the galaxies themselves as tertiary indicators — they approached the problem again. In addition to several new techniques and more powerful methods of calibration not used by Hubble, they also had the advantage of a bigger telescope: the 200-inch Palomar reflector. The result: another decrease in Hubble's constant. The new value was approximately 50 km/sec/Mpc, corresponding to an age of 20 billion years.

But not everyone agreed with Sandage and Tammann. One of the most prominent of the dissenters was Gerard de Vaucouleurs of the University of Texas. He had been working on the same problem for years and had been consistently getting a value near 100 km/sec/Mpc. Others, including Sidney van den Bergh of Canada, were finding similar values.

Who was correct?

Many astronomers felt that a new "candle" should be calculated for determining distances. Marc Aaronson of Steward Observatory, John Huchra of Harvard, and Jeremy Mould of Kitt Peak National Observatory attempted to introduce one: In 1979, they announced that — with a new technique — they had obtained a value intermediate between that of Sandage and de Vaucouleurs. Later, by looking at galaxies in a different direction of space, they arrived at a value that agreed reasonably well with that of de Vaucouleurs.

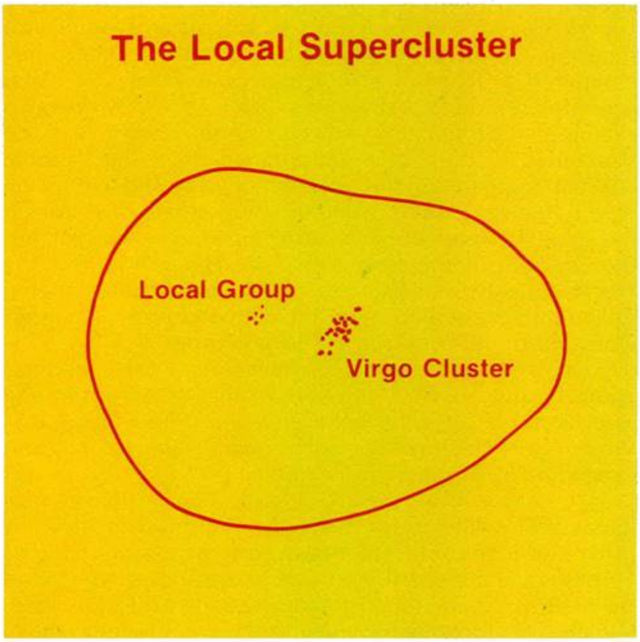
The technique used by Aaronson, Huchra and Mould wasn't entirely new. It had been used earlier in a different region of the electromagnetic spectrum by Brent Tully of the University of Hawaii and Richard Fisher of the National Observatory. Basically, the technique "weighed" a galaxy by its rotation. Astronomers had known for years that the more massive a galaxy is, the faster it rotates. And since rotation tends to broaden the 21 cm emission line from the hydrogen in the galaxy (due to the Doppler effect), the faster a galaxy rotates, the broader its 21 cm line is. Tully and Fisher used this to determine the masses of distant galaxies, and from it they obtained a measure of their brightness. By simply measuring the widths (i.e. the Doppler broadening) of 21 cm lines, they could determine how bright a galaxy should appear. Then by directly observing this galaxy, they could see how bright it actually was. A comparison of these two values gives the distance to the galaxy.

Although the method may, at first sight, look simple and straightforward, it was actually plagued with difficulties. Numerous corrections had to be applied. When measuring the rotational speed of the galaxy, they needed an "edge-on" view. Most galaxies they measured were at some angle, and corrections had to be made for this. Further corrections were needed for extinction due to dust in the galaxies. Since Tully and Fisher were using photographic plates that were sensitive to blue light, these corrections were rather extensive.

Because of these problems, the value that Tully and Fisher obtained was greeted with skepticism. But Aaronson, Huchra and Mould were convinced that the technique could be valuable — if it was used correctly. The key, they believed, was to switch to the infrared. Although in some cases they used published data, for the most part Tully and Fisher photographed — with blue sensitive plates — distant galaxies which contained mainly red stars. It made more sense, Aaronson and his associates believed, to observe these galaxies in the infrared. They soon discovered that if they did this, fewer corrections were needed since infrared radiation easily penetrates dust.

They made their first observations on galaxies in the general direction of the constellation Virgo (though some were also made in the direction of Ursa Major). The new value for the Hubble constant was 65 km/sec/Mpc. When he saw their result, de Vaucouleurs suggested they use their technique on galaxies in other directions — well away from Virgo. They did, and found a quite different value — 95 km/sec/Mpc.

Why would this "constant" be different in different directions? To answer this, we look back a few years to the early work on galaxies done by de Vaucouleurs. He began studying clusters of galaxies in the early 50s and, after studying our Local Group (which consists of about 30 galaxies) and several other groups, he became interested in how these clusters grouped themselves. Was there a higher order structure to the universe? In 1953 he published a paper suggesting that there was. Our local group, according to his observations, was part of a local supercluster. This supercluster is dominated by a particularly large cluster (containing about 2500 galaxies) in the direction of the constellation Virgo, which we now refer to as the Virgo cluster. We are about 60 billion light-years from the center of the local supercluster, while the Virgo cluster is close to the center.



When de Vaucouleurs calculated the Hubble constant, he did not rely on galaxies in only one direction. He determined its value for several different directions within our local supercluster, and, to his surprise, the constant was different in different directions. It was least in the direction of Virgo, and greatest away from the constellation.

In measurements of this type, errors and uncertainties are inherent, so many astronomers did not accept de Vaucouleurs' results. Accepting them requires that we accept living in an unusual region of the universe. It is easier to suppose that we live in an average region of space, free from any anomalous behavior — and this is what Sandage and Tammann's results indicate. Most texts and other books therefore quote the age given by Sandage and Tammann — 20 billion years.

Despite the general acceptance of the Sandage-Tammann value, de Vaucouleurs feels that his technique gives a more legitimate value than theirs. He criticizes their method on several grounds, pointing out, for example, that he and his co-worker Gerald Bollinger make corrections for extinction by dust in our Galaxy while Sandage and Tammann do not. But Sandage and Tammann are confident that their measurements show a dust-free zone in either direction away from us toward the faces of our Galaxy. They insist there is no need for a correction. Who is right has yet to be resolved.

De Vaucouleurs also points out that Sandage and Tammann use only one prime indicator — Cepheid variables — while he uses five: novae, Cepheids, RR Lyraes, supergiants, and eclipsing variables. He also calibrates each of his methods in several different ways. He further argues that he uses more secondary indicators than they do, and points out that he used 300 galaxies in his survey — compared to 100 in the Sandage-Tammann survey.

The recent work of Aaronson, Huchra and Mould also seems to confirm de Vaucouleurs's results. After they computed a value in a direction away from Virgo that agreed with de Vaucouleurs's value, they decided to examine the situation further. And soon, like de Vaucouleurs, they also determined that the Hubble constant is greatest in the direction of Virgo and least in the direction away from it, while in intermediate directions it has values between these two extremes. On the basis of this, they convinced themselves that we apparently live in a "local anomaly." As Huchra says, "Our local cluster is being pulled into the center of our local supercluster — in other words, in the direction of the Virgo cluster."

De Vaucouleurs is also convinced that we live in a local anomaly, but his view differs from that of Aaronson and associates. He does not believe we are simply falling into Virgo. Instead he invokes a rather complicated rotating and expanding local supercluster model.

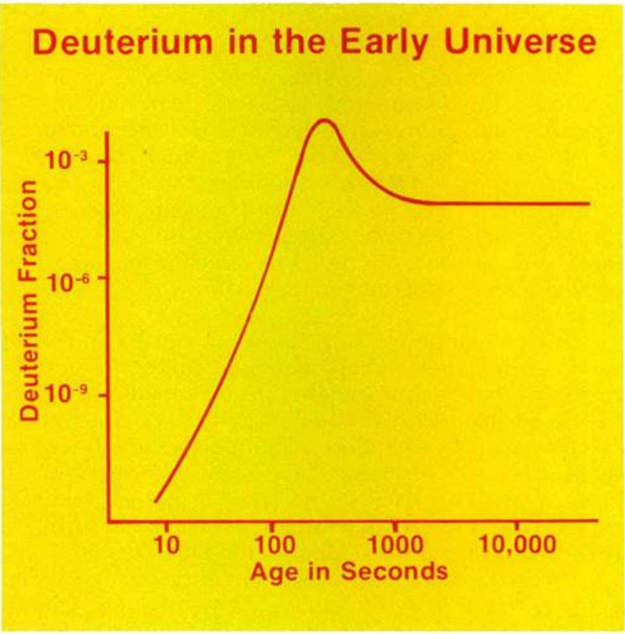
But surely, if we do live in a local anomaly, we must have other evidence for it. We do, but unfortunately this other evidence confuses the issue to some extent. In 1963, a monumental discovery was made in astronomy. We found the "leftover" radiation from the Big Bang explosion. It has cooled considerably — now only 2.7 degrees above absolute zero — and its wavelength has changed, moving into the mircrowave region of the spectrum. But it's still there and it permeates the entire universe. Scientists soon began to wonder if it was *isotropic* — if its intensity is the same in all directions around us. If there is an *anisotropy* — of varying intensity — that would be important. We could use it to tell how fast we are traveling through the universe. Several groups began taking measurements. At first it seemed the radiation around us is uniform, but when scientists turned to more sophisticated equipment they finally found a difference. There *is* an anisotropy, and it indicates that our Galaxy is traveling, not in the direction of the Virgo cluster, but in the direction of the constellation Leo, with a velocity of about 500 km/sec. Leo lies at an angle of about 43° from the Virgo cluster in the sky. To further complicate things Vera C. Rubin and several associates believe they have detected a velocity of about 600 km/sec in a third direction almost perpendicular to that of the Virgo cluster.

Complications like this keep cosmology interesting! Until the controversy is completely resolved, we can't be sure where we are going. Assuming, though, that one of them is correct, we *can* say that the universe is not expanding uniformly around us. If we assume we are falling toward Virgo, for example, the galaxies in this direction will not appear to be expanding away from us as fast as they should be. And if we calculate the age of the universe using data supplied by these galaxies, we will get an age that is too large. If we are indeed in a local anomaly, it is important that we take our measurements outside of it to get a reasonably correct age for the universe.

Aaronson and his associates have done this. They have determined Hubble's constant using galaxies in many different directions, but all well outside of our local region. The average result of these determinations is about 95 km/sec/mpc, corresponding to an age of approximately 10 billion years.

But Sandage and Tammann still say their data indicate no local anomaly — or at least that it's not nearly as large as de Vaucouleurs and Aaronson and his associates claim it is. Sandage points out that our only truly accurate measurements are those taken in our immediate neighborhood of space. When we attempt to take measurements of distant galaxies, these measurements are difficult and the accuracy is not high. But it's the extremely distant galaxies that are of the greatest interest.

What about other evidence? There is some interesting evidence that seems to favor the higher value of H_0. It was published by Donald Lynden-Bell of Cambridge University in 1977. He was studying superluminal sources — sources (usually two quasars) that appear to be separating at velocities greater than the speed of light. We know, of course, that this is impossible, because special relativity tells us the speed of light cannot be exceeded in our universe. Lynden-Bell has devised a way of explaining these superluminal sources so they are each moving out from some center point with the velocity of light only — and thus not contradicting relativity theory. The only major requirement of his theory is that we assume the Hubble constant is 100 km/sec/Mpc, rather than 50 km/sec/Mpc. Lynden-Bell's idea is based on a model he formulated for the ejection of two beams of light out of a quasar — and of course we are still not certain that his model is correct. Nevertheless, his idea is interesting.



According to what we've seen so far, it might seem that most of the evidence indicates the universe is 10 billion years old. This is actually far from the truth. There are two other independent ways of determining the age of the universe, and neither of them indicate that the universe is as young as 10 billion years. Actually, both of these methods give us only the age of our Galaxy, but nevertheless that does give us a *lower limit* on the age of the universe.

The first of these methods arises from our knowledge of the life cycle of stars in globular clusters. If we make color-luminosity plots of several globular clusters, we find their main sequences are not well populated. Usually there are no stars in the central and upper parts. At some point there is a turnoff or breaking point where there are stars below this point but none above. Using our knowledge of stellar evolution and the position of this turnoff point, we can calculate the age of the globular cluster. Plots of this type have been made for numerous globular clusters and they tell us that their ages range from about 8 to 18 billion years. And, as far as we know, stellar aging models are fairly reliable. This leaves us with a dilemma: How could we have 18 billion-year-old globular clusters when the universe is only 10 billion years old?

The second method of age determination involves observing the speed at which radioactive substances decay. All radioactive substances have what is called a half-life. This is the time needed for half of the nuclei present at any given time to decay. In some cases, the half-life is only a few minutes, but in others it is millions of years. Since these substances presumably formed when the solar system formed, we have a method of determining how long ago that was. And again we find ages greater than 10 billion years.

How can we explain this? Does the universe have to be 20 billion years old, as suggested by the data of Sandage and Tammann? Beatrice Tinsley of Yale University has considered this problem, and has shown that there is a way that the 10 billion-year-old universe predicted by de Vaucouleurs, and by Aaronson and his associates, can be made consistent with 18 billion-year-old globular clusters.

To make this solution work, we must remember that 10 billion years is a maximum age: if the expansion of the universe is decelerating, its age will be less. Also, this number is based on the presently accepted theoretical model of the universe: the Friedmann model. But what if the Friedmann model is not correct? Tinsley has shown that if the universe is accelerating, rather than decelerating as predicted by the Friedmann models, then the two numbers can be consistent. The only legitimate way, however, that we can theoretically make the universe accelerate is to bring back the *cosmological constant*. This is a special constant that Einstein invoked many years ago to "hold the universe together" — in other words to stop it from expanding indefinitely. Einstein soon discarded his cosmological constant: "The introduction of this constant into my equations was the biggest blunder of my life," he later said. If he had not introduced it, he might have predicted the expansion of the universe before it was found observationally.

Tinsley notes, however, that a Hubble constant of 100 km/sec/Mpc creates a serious problem: the production of deuterium in the early universe is not consistent with such a large value. If it were so large, our standard picture of some of the events of the early universe would have to be revised, and in particular we would have to come up with some other source for the origin of the deuterium — a non-cosmological source.

Tinsley has also been working with J. Richard Gott and James Gunn of Caltech and Hale Observatories and David Schramm of the University of Chicago on still another method of determining the age. In it, the constraints imposed by all known methods of determining the age are plotted on a graph on which one axis is the Hubble constant and the other is the average density of matter in the universe. The region that is completely consistent with all methods can then be seen easily. In a sense, they are squeezing in on the best age. This "best age" seems to lie between 13 and 18 billion years.

More recently, Schramm and several colleagues have developed a modification of this scheme. They determine, first of all, how the age is affected by the predicted amount of helium in the universe, and then they plot age versus helium content for the three standard methods of determining the age. They arrive at a "best age" of from 15 to 18 billion years.

Schramm feels that if the age of the universe is found to lie outside this range, we would be forced to question the standard cosmological models and perhaps the standard globular cluster models. When asked about the relative merits of the three basic methods of determining the age, he said, "The one that uses the Hubble constant is probably the least accurate. There are just too many uncertainties in it. It is perhaps best at this stage to use it to study the evolution of galaxies." The effects of evolution are, indeed, important. As we look out into the universe we know we are looking back in time, and therefore we are seeing galaxies as they were millions, and in some cases almost a billion years ago. There have been efforts to take this into consideration, but so far we are not certain how successful they are.

Vittorio M. Canuto and S. H. Hsieh of NASA's Goddard Institute for Space Studies point out a further difficulty. They remind us that there are two physical ways of measuring time — in other words, there are two time scales in the universe, each based on its own "clock." The first is time as measured by the atomic clock based on atomic forces. The second is based on gravitational interactions, for example, two stars rotating around one another.

Canuto's and Hsieh's present work seems to indicate that these two scales are not equivalent. This means that there could be two ages to the universe: an atomic age and gravitational age. Canuto says that his results indicate gravitational age is greater than atomic age. He bases his judgment on a study of the Moon's motion in which he compared its periodicity as measured with atomic clocks to that measured with gravitational clocks. He found they are not precisely equal.

Usually in cosmology, we assume the two time scales are equal. But Canuto says that there are only two ways that we can determine whether or not they are actually equal. If we had a satisfactory unified field theory that united the fundamental forces of nature, that theory would tell us the connection. Of course we have no such theory — yet. The second method of determining the relationship is by accurately measuring some physical relation, such as the periodicity of the Moon — using the two different types of clocks — to see if they give the same answer. Canuto has done this, and claims they don't.

It is entirely reasonable, according to Canuto, that these scales would not have been the same in the past. Our universe is expanding, and at one time all the matter in it was in a singularity where all the laws of physics vanish. Indeed, recent calculations indicate that the forces of nature were a single force at the beginning.

Canuto explains that there are also important problems in the way we presently calculate the age of the universe. The method that Sandage and Tammann employ, as well as that of de Vaucouleurs and also Aaronson, Huchra and Mould, uses mixtures of gravitational and atomic quantities. Thus it gives a mixed age.

Finally, Jacob Bekenstein of the University of California and Amnon Meisels of Ben Gurion University in Israel disagree with Canuto. They have examined the two different time scales using data from various solar system experiments and find that the two scales are equal. They feel that Canuto's theory has an inconsistency in it.

At least one point seems to be clear: there is still a lot of work to do before we know the true age of the universe. We must find out for certain if we do live in an anomaly, and if we do, what direction we are traveling in and at what speed. We also obviously need to develop some new techniques, particularly some new standard candles. Schramm feels that supernovae could eventually be our best candles, perhaps because they can be seen in the most distant galaxies. But we have to learn a lot more about them before they will be of any value to us.

We still do not know exactly how old our universe is. Despite the many approaches, the theories, the delicate measurements and computations, the answer still eludes us. But astronomers are working hard to develop the needed techniques and tools, so the answer to this age-old question may eventually be found.

AstroMart

Astro-Mart is a free service department available to all our readers. No subscription is necessary to place an ad, but we can allow only 2 noncommercial ads per person per year. You are limited to 40 words including your name and address. All ads are, of course, subject to editorial review for suitability. Be sure to allow 4-6 months for your ad to appear. AstroMedia assumes no responsibility for statements made in classified ads, nor for the quality of advertised items. We cannot acknowledge classified orders nor provide checking copies.

Astroscan Renewal Contest Winner

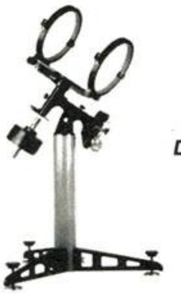
April 1981
M. Thorpe
Springfield, MA

ADVERTISER LISTING

ADVERTISER	PAGE
Abraxas Electronics	73
Ad-Libs Astronomics	27
Astro-Cards	75
Astronomy New England	65
Astronomy Shoppe	73
Celestron International	55, 88
Coast Bavugation	74
Cosmic Connections	60
Coulter Optical	25
Criterion Mfg. Co	29,87
Data*Soft of N.H.	72
E&W Optical	73
Edmund Scientific	76
Fiber Light	74
GL Enterprises	76
Hansen Planetarium	63
Hirsch, Edwin	72
Keplet Project	65
Luft, Herbert	76
Lumicon	54
McMillan Publishing	46
Meade Instruments	2-3,44-45
Moonshadow Expedition	76
Optica b/c	74
Optron Systems	75
Orion Telescope Ctr	77
Pacific Inst.	72
Pi-in-the-Sky	73
Professional Aids	60
Questar Corp.	51
Rolex	23
RVR Optical	74
S&S Optika	54
Sky Publishing	43, 61
Sky Research	75
Sky Scientific	74
Space Graphics	63
StarTracker	60
Super-T	74
Tele Vue Optics	65
Texas Nautical Repair	76
Tomlin Ent.	75
Tuthill, Roger	52-53
University Optics	64
Viking Fund	86
Woodstock Products	73

PRE-RETIREMENT SALE!

We have enjoyed serving the astronomical community for 14 years; always striving to produce custom quality equatorial mounts. Retirement is upon us and now is the time to let go of our entire inventory at reduced prices!



6" and 8" EQUATORIAL MOUNTS

DRIVES • CIRCLES

INDIVIDUAL CASTINGS AND PARTS

Catalog sent free in USA • $2 Foreign
Dealer Inquiries Invited

Pacific Instruments

P.O. Box 1876, Pacoima, CA 91331 (213) 896-3016

FOR SALE — Celestron 8, special coatings, tripod, wedge, 5 eyepiece, Barlow, porro prism, 10x40 finder, 3" solar filter, dewcap, tray, all mint, best offer over $850. Contact John Eliason, Box 17-A, Sayner, WI 54560. Phone (715) 542-3233 weekdays only.

FOR SALE — Meteorites from Henbury Crater Austrailia, metalic, about 3/4", $10 each. Please send postal money order. Contact Richard Heimlich, 23871 Moritz, Oak Park, MI 48237.

FOR SALE — New 21" f/4 Dobsonian, wheeled base, semi-permanent collimation, 3" thick pyrex mirror. Serious inquirers, please send SASE to Robert Kramer, Drawer "D", Everglades City, FL 33929. Phone (813) 695-4579.

FOR SALE — 4" Quantum, complete, excellent shape, offers please. Also, want books by Payne-Gaqoschkin. Contact George Bodo, RR #1, Box 338B, Voluntown, CT 06384.

FOR SALE — Quartz 19-3/4" f/5, parabolic mirror, tested but not coated, $6000. Contact R. McIntyre, 5114 W. 149 St., Brockpark, OH 44142. Phone (216) 433-4560 or (216) 886-2829.

FOR SALE — 9" f/4 Newtonian tube assembly, mirror has some blemishes, but don't affect viewing, very nice, $120 ppd. Contact Robert Webber, 1110 Columbus St., Sun Prairie, WI 53590.

FOR SALE — Jaegers equatorial mount and pedestal, only used twice, like new, $50. Contact Dale Dufresne, 419 Pine St., Norco, LA 70079.

TRS-80 OWNERS! Two college/pro. level mathematical astronomy packages: A-Eleven multipurpose subprograms, B-Ten sophisticated subprograms. Call/Write for information. Documentation pkg. $2.00 ea. Cassette $14.95 (Disk - $24.95) ea. Model-1/3 Level 2-16K. Visa/MC 603-424-5217 **DATA*SOFT of N.H., 22 Stevens Ave., Merrimack, N.H. 03054**

Edwin Hirsch

COMPETITIVE PRICES
PERSONAL SERVICE
FREE EXPERT ADVICE

Criterion: *New 4"* **Dynamax** — *RV6 - RV8* **Dynascope**
Tele Vue: Plössl *Eyepieces — Superior Performance*
Coulter Optical: Odyssey 1 — *13.1" Dobsonian*
Meade: *Schmidt-Cassegrain and Newtonian*
Daystar: *Hydrogen-alpha Solar Filters*
Celestron • Edmund • University

EDWIN HIRSCH, Well known to astronomers for his remarkable filtergrams of the Sun taken with the famous DAYSTAR H-alpha Solar Filter, shows our Sun and its thousands of faces of ever-changing detail. **EDWIN HIRSCH** also serves on the staff of Astronomy Island.

17 YEARS ASTRONOMY EXPERIENCE to Help You Select Optimum Telescope and Accessories for Your Personal Needs.

Edwin Hirsch
168 LAKEVIEW DR.
TOMKINS COVE, N.Y. 10986 • (914) 786-3738

FOR SALE — Astro-computer control model 1129, CM astronomical clock with manual computer connectors, like new, $195. Contact Lou Skloot, 367 Hewlett Ave., Merrick, NY 11566. Phone (516) 221-3535 or (516) 868-8199.

FOR SALE — ASTRONOMY back issues: June 1976 through May 1979, July 1980 through December 1980; *Sky & Telescope* 1969, 1971, 1972, all issues, July 1975 through December 1980, excellent condition, best offer. Contact Robert E. Sullivan, R#4 Box 332, West Burlington, IA 52655. Phone (319) 753-0360.

FOR SALE — Meade (model 305) 3.1" equatorial refractor, 1200 ml Fl, f/15, 1-1/4" eyepiece, excellent condition, only six months old, $505 plus I will pay half the shipping cost. Contact Howard Kiyota, 905 Evergreen Ave., Boulder, CO 80302. Phone (303) 443-7370.

FOR SALE — 4" Quantum $1000; 6" Quantum barrel with split rings, $1500; Quantum 100, $550; 6" solar filter, $200; 4" solar filter, $1200; 3-1/2" Duplex Questar cervit, $1500; 0.7A° Ha filter, $1000; all with special coatings, superb condition. Contact Rodger W. Gordon, 637 Jacobsburg Rd., Nazareth, PA 18064. Phone (215) 759-6805.

FOR SALE — Meade 3.1" refractor (model 305) with six 1-1/4" eyepieces, electric clock drive, 6x30 view finder, illuminated reticle, camera adapter, accessories, and more, mint condition, must sell, best offer. Contact Tom Streeter, 1110-D Schaub Dr., Raleigh, NC 27606. Phone (919) 851-5937.

FOR SALE — 8" Dobsonian reflector, Coulter mirrors; Koneg (24,16,12mm) and Meade (7mm) eyepieces, $300 plus shipping or best offer. Contact Duke Glascock, 375 Severn Dr., Annapolis, MD 21401. Phone (301) 224-2580.

FOR SALE — *Black Holes* by Walter Sullivan & *The Illustrated Encyclopedia of Astronomy and Space*, edited by Ian Ridpath. Brand new, $30 for both, or $16 each postpaid. Contact Roy Patton, 713 Edgewood Rd., King of Prussia, PA 19406.

FOR SALE — Celestron 5, 12 & 25mm oculars, wedge and tripod, $720; I will ship. Contact Pete Klippell, 1007-1/2 S. Pickard, Norman, OK 73069. Phone (405) 329-8760.

FOR SALE — Hewlett-Packard HP-67 magnetic card programmable scientific calculator. Includes security cradle and basic library of 22 cards, all in excellent condition, $350. Contact John Schneider, 1217 Waverly Rd., Sandusky, OH 44870. Phone (419) 625-4104 evenings.

CELESTRON TELESCOPES
ON DISPLAY AND IN STOCK
E & W OPTICAL, INC.
2420 EAST HENNEPIN AVE.
DEPT. AM
MINNEAPOLIS, MINN. 55413
612-331-1187
SEND FOR PRICE LIST "A"
Astronomy supplies and accessories

ARE YOU ALIGNING MORE AND VIEWING LESS?

CELESTRON OWNERS
POLARIS IS AT YOUR FINGERTIPS WITH THE NEW AZIMUTH ALIGNER FROM:

Abraxas Electronics
P.O. Box 1188
Littleton, CO 80160
(303) 979-6102

A1

ANNOUNCEMENT — The second edition of the international Exhibition-Congress "ASTRON '82" will be held Mar. 4-7, 1982 at the Exhibition Centre of Novegro, located next to the Milan/Linate airport, Milan, Italy. For information contact COMIS Lombardia, Via Boccaccio, 7-20123 Milano, Italy.

ANNOUNCEMENT — The Yankton College Observatory will have open observatory nights, the second and fourth Tuesday of each month. The Astronomy Club also sponsors events open to the public. Contact Joseph R. Dell'Aquila, Director of the Clarke Observatory, Yankton College, Yankton, SD 57078. Phone (605) 665-3661.

ANNOUNCEMENT — If your are "sirius" about astronomy, then it's time to join Spectra. A monthly news magazine with information on planetary, stellar, solar, terrestrial, galactic, and aeronautic information will be sent to those who join. Write to Spectra, 1961 Kaptey Ave., Coquitlam BC, Canada V3K 5Z7.

STOP WASTING YOUR TIME!

WITH our *FINDER Software, you could be observing accurately in less than five minutes WITHOUT Polar Alignment!

*FINDER

- *Requires fixes on only two stars for fast operation!
- *Converts a. actual to the apparent co-ordinates shown on your setting circles!
  b. 'apparent' to actual co-ordinates!
  c. to the 'apparent' position of Polaris!
  All at the touch of a single button!
- *Results always current-uses time from your watch for convenience!
- *90 sec. initialization time, average of 22 sec. conversion time!
- *Data Storage for interrupted viewing! (HP-41C, 67, 97, & TI-59 only)
- *Available for HP-34C, SR-52, TI-58C, BASIC or FORTRAN ($60) or HP-41C, 67, 97, or TI-59 ($55)

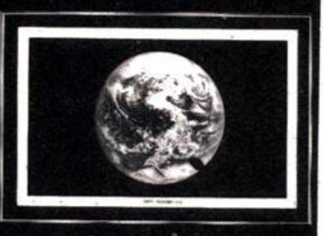
We have many other programs for the astronomer, scientist, gamesman, or home user, amateur or professional. Send $1 for our catalog (will be applied to your first order). Our programs are available for all calculators and languages listed above. **CUSTOM REQUESTS WELCOMED!!!**

π PI | IN THE SKY SYSTEMS

P.O. Box 4095, Pocatello, ID 83201
Phone: (208) 234-2033

color SPACE photos

bring outer space into your home or office



• JUPITER • EARTH RISE • FULL EARTH
• MARTIAN SUNSET • SATURN

3'x2' Full Color Reproductions from Official NASA Color Photos Ideal for Home, School or Office

NASA'S Most Beautiful scenes from space are now available as large, titled, **Full-Color Prints.** Taken from deep space these beautiful color photos reveal for the first time in history the grandeur of outer space and its celestial splendor. For greatest clarity and fidelity they are reproduced by the highest quality, full color lithography on heavy Kromekote paper. Available unframed, or quality framed with color coordinated mat, contemporary silver chrome frame, and non-glare glass.

FRAMED	UNFRAMED
$79.95	$19.95 each
$10.05 UPS Shipping	$3.05 UPS Shipping

"Fantastic!" "Tremendous Pictures!" "Incredibly Beautiful!" are a few of the superlatives expressed about these reproductions.

ORDER NOW TOLL FREE! 1-800-824-7888, Op. #462
in Calif. 1-800-852-7777, Op. #462

FREE Catalog Full-color

Woodstock Products
P.O. Box 2519 Dept. A, Beverly Hills, California 90213
"BRINGING OUTER SPACE DOWN TO EARTH"

The Finest Telescopes and accessories...from the leader of low prices and fast reliable service.

Celestron

C-90 Spotting scope	$290
C-5 Base price	$619
C-8 Base price	$765
C-11 Base price	$2350
C-14 Base price	$4995

Meade
Please call or write for quotes.

Edmund

Astroscan 2001	$165

All above telescopes (ex. C-11, C-14) shipped free in continental U.S.

Similar savings on all other telescopes and accessories. We personally pick up Celestron and Meade telescopes from the factory. Our direct contact with the factory insures complete control of your order. Most orders available for shipment within 24 hours. Fast delivery on C-14s too. All telescopes are fully warranted for an entire year, plus our own 30-day unconditional guarantee which entitles you to a full refund with no questions asked.

SOLAR FILTERS
Our filters are completely safe and slip onto most telescopes in a second. We guarantee our filters to equal or surpass any similar filters on the market in quality and workmanship at any price.

2001 Astroscan	$31.95
5-6"	$34.95
8"	$39.95

please specify telescope model all prices include postage other sizes available

PLOSSL EYEPIECES

7.4mm, 10.4mm, 17mm, 26mm	$49.95 ea ppd.

8 x 50 Right-Angle Finder

C-8, 2080	$44.95

OLYMPUS OM-1 ASTROCAMERA
One of the finest astrophotography cameras available. Comes with clear screen, lockup mirror, cable shutter release and T-ring. $275 ppd.

Send for our complete listing of acccessories. We also carry a large selection of books and star atlases.

ASTRO WALL MURALS
Moon & Stars 8'8" x 20'9" Earthrise 8'8" x 13'8"
vinyl-coated $69.95 uncoated $39.95
Send for free brochures.

Free discount price list sent on request, or you may order any one or all of the following: Celestron 32-page color catalog $1.50. Meade 50-page catalog $2.25. Edmund Scientific catalog $1.00. (Add $1.50 each for airmail outside North America.

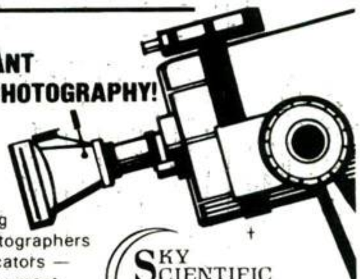
Free shipping on most items in the continental U.S. Allow 2 weeks for personal checks to clear. California residents add 6% sales tax. Shipping extra on COD and credit card orders.

THE ASTRONOMY SHOPPE

Box 2001C
Newbury Park, CA 91320
10 a.m. to 6 p.m. Mon. thru Fri.

Call
805-499-1501

INSTANT ASTROPHOTOGRAPHY!



For beginning astrophotographers and educators — cameras accept Polaroid® film packs for instant celestial photography

SKY SCIENTIFIC
28561 Highway 18
PO Box 184
Sky Forest, CA 92385

Tel: (714) 337-3440

For advanced amateurs and professionals — our cameras also accept conventional sheet films. Prices start at only $75. Off-axis guider models from $105. Free brochure and photo

Authorized dealer for CELESTRON and MEADE

4 OPTICA b/c CATALOGUES

ATM
ASTROPHOTOGRAPHY SYSTEMS CAT 1977

(1) **"Telescopes and Accessories"** - over 250 items. (2) **"Astrophotography"** - Systems, supplies, special films, chemicals, over 500 items. (3) **"Publications & AVA"** - over 300 books, atlases, maps, slides, posters, recordings, globes, etc. (4) **"ATM"** - goods for the telescope maker, - over 400 items. Each catalog - 50¢; all four - $1.50 for handling and postage. Send cash, check or U.S. stamps. Also receive **FREE** current Astronomical Events Calendar, a wealth of useful information. **FOREIGN** — Each catalogue $1.00; all four $3.00. Must be paid by an International Postal Money Order or a check drawn in U.S. Dollars on any bank in the U.S.A. For Airmail, add $2.00.

OPTICA

OPTICA b/c Company
ASTRONOMY DIVISION
4100 MacArthur Blvd., Oakland, Calif. 94619

FOR SALE — Rare, antique brass refractor, circa 1850, signed; 2 sections, 38" extended, 21" closed, 40mm, 12x excellent optics, 5 lens upright image, beautiful collectors item, 2-1/2" O.D., $300 postpaid. Contact Ken Baker, Box 312, Little River, SC 29566. Phone (803) 249-3375.

FOR SALE — ASTRONOMY back issues: October 1973 through December 1973, January 1974 through November 1974, February 1975 through August 1975, October 1975 through December 1975, all of 1976, January, March, and July 1977, good to excellent condition, 42 issues for $50 plus postage. Contact Dale Samuels, 156 Spruce St., Bridgewater, MA 02324. Phone (617) 697-9123.

FOR SALE — Cave 8" f/4.5 richfield reflector telescope, 25mm orthoscopic eyepiece, yields 2° field of view, no finder necessary, portable equatorial mount, heavy 1-1/4" focuser, 6mm eyepiece and Barlow included, $450. Contact Wayne Reed, RR#3 Box 607, Linton, IN 47441. Phone (812) 847-2165.

LEARN ASTRONOMY AT HOME

For the first time the world famous Coast Navigation School home study course in astronomy is available as a self-study program* This completely self-contained course will introduce you to the wonderful world of the heavens in only a few short weeks. Proven successful by thousands of students over the past fifteen years. Special prices on Celestron telescopes. Call Toll Free for details 800-638-0420.

*Optional individualized instruction and certificate program available.

Coast Navigation
Dept. 51 1934 Lincoln Dr.
Annapolis, MD 21401
(301) 268-3122

Please send me your complete visual Astronomy course for only $27.

Name ____________________

Address ____________________

City __________ State _____ Zip _____

☐ Please send me your complete school catalog.

NEW ARRIVAL — COMET SEEKER

Giant 4" Objective 30x Complete with Helicoid Focusing, Micrometric Controls, 45° Viewing Angle and Adjustable Tripod — Special Introductory Price $549.00 ppd in Continental U.S.A. Optional Interchangeable Eyepieces — 15x, 20x, 25x, 40x, 50x, 60x — $40.00 each

For Complete Information on Our Entire Line of Telescopes, Binoculars and Accessories, Send for our Large Assortment of Illustrated Literature — $3.00 U.S.A., $5.00 Foreign

Write or Call 7 Days a Week 'till 8:30 p.m. We Gladly Accept VISA & MASTER CARD Orders. Foreign Orders Also Our Specialty.

R.V.R. OPTICAL, P.O. Box 62A
Eastchester, N.Y. 10709 (914) 337-4085

CELESTRON
QUESTAR
MEADE
UNITRON
CARTON
GOTO
FUJINON
ASKO
KOWA
MOZAR
NIKON
ROYAL
PANOP
VIXEN
TELESCOPE WORLD
PENTAX
VARO
NOCTRON

WANTED — A copy of *Splendour of the Heavens*. Contact Bruce Bond, 8050 N. Port Washington Rd., Milwaukee, WI 53217. Phone (414) 351-2326.

WANTED — Meteor photographers for the new Upsilon Pegasid Meteor Shower in August. Send SASE for free instructions to Florida Fireball Patrol, 215 Osage Dr., Indian Harbour Beach, FL 32937.

WANTED — 8 or 10" mirror, 1/8 wave accuracy and at least f/5.6, or complete kit for grinding my own. Also, 2.5" diagonal mirror; both mirrors must be in good condition. Contact Jenny Pulczinski, Greenbush, MN 56726. Phone (218) 782-2932.

WANTED — Smyth's *Cycle of Celestial Objects*, Barns' *1001 Celestial Wonders*, Proctor's *Half Hours with the Telescope*, and Dimitroff and Baker's *Telescopes and Accessories*. State condition and price. Contact Alan Sawicki, 21 Barr St., Salem, MA 01970.

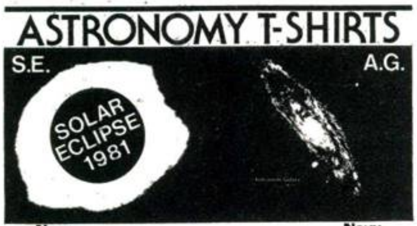
WANTED — Correspondence with persons (ages 18 and over) whose interests include astronomy, cosmology, space-flight, home computers, amateur radio and art. Contact William Dent, 335 Main Rd., Broomfield, Chelmsford, Essex, CM1 5BB, England.

WANTED — ASTRONOMY back issues: September through December 1973, February 1974. Contact Stephan Salchow, 200 Christie St., Leonia, NJ 07605.

WANTED — Estimates for correcting and/or refiguring a 20" f/2.6 mirror (tool not available). Put your talent to work! All capable persons are encouraged to respond; all responses will be answered. Contact Tom Webb, P.O. Box 5603, Augusta, GA 30906.

WANTED — Newspaper clippings, photographs, and personal accounts of UFO sightings, contacts, etc., for UFO research project. Also, suggestions for good stargazing music. Contact Project Skywatch '81, Pennsylvania UFO Research Center, 503 2nd Ave., 1st Apt., Altoona, PA 16602.

ASTRONOMY T-SHIRTS



Navy **Navy**

TOP Quality - Only $6.95

Send to: Super—T
2345 NE 52nd St.
Gainesville, FL 32601

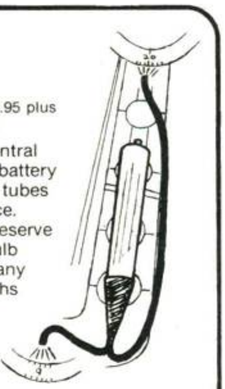
Include $1.50 Postage

Amount enclosed ______
(outside U.S. & Canada — Add $3 postage. Please send in U.S. funds)

	S	M	L	X
S.E.				
A.G.				

NAME ____________________
ADDRESS ____________________
CITY ____________________
STATE __________ ZIP __________
Please charge this to my account
SIGNATURE
ACCT #
EXP. DATE

FIBER OPTICS TO ILLUMINATE YOUR SETTING CIRCLES



INTRODUCTORY PRICE $16.95 plus $1.50 Shipping and Handling

Optical fibers use one central light source to conserve battery life. Wire reinforced light tubes adjust and remain in place. Projects red beams to preserve night vision. No bulky bulb ends. Easily attaches to any mount. Light guide lengths adjustable. Instructions included.

SEND CHECK OR MONEY ORDER TO:
FIBER LIGHT • Box 8228
• Prairie Village, KS 66208 • 1-913-381-4000

WANTED — Correspondence with persons (ages 14-18) interested in science, space, astronomy, stamps, Space Shuttle, NASA, music, mailing connections, and space exploration. Contact George R. Lewycky, 7 Durst Dr., Milltown, NJ 08850.

WANTED — Correspondence with persons (ages 12-15) interested in astronomy and other aspects of science. Send information about yourself to Eric Haught, 11952 Auburn Rd., Chardon, OH 44024.

WANTED — *Astronomical Photography at the Telescope* by Rackham; *Stargazing with Telescope and Camera* by Keene; *Astronomical Photography* by de Vaucouleurs. Send prices to David McConnell, 66 Hamilton Crescent, Stevenston, Ayrshire, Scotland.

WANTED — Correspondence with persons (preferably ages 23 or over) interested in physics, math, astronomy, cosmology, astrophysics, Reimannian geometry, space-time and especially black holes, or any other technical subjects. Contact Daniel T. Sandefur, 2123 E. Skelly Dr., Apt #223, Tulsa, OK 74105.

WANTED — A copy of the science fiction novel *The Earth Dies* by Clark Darlton, a Perry Rhodan book, #41 in the series. Contact Daniel T. Sandefur, 2123 E. Skelly Dr., Apt. #223, Tulsa, OK 74105.

WANTED — Correspondence with any professional astronomers in the U.S. I am a sixteen year amateur seriously thinking about an astronomical career. Contact Mr. David Abbou, 6115 Rose Hill Dr., Alexandria, VA 22310.

WANTED — Correspondence with anyone (ages 12-15) interested in astronomy, math and chess. Contact Thomas Rix, 3611 Heschel Lane, Winston-Salem, NC 27106.

WANTED — Correspondence with scientists of any age, ethnic background, for the broad educational and cultural foundation of a six-year-old intellectual prodigy. Primary interests: astronomy, cartography, languages. Contact Jane Henson, c/o 1712 S. Congress, Austin TX 78704.

WANTED — Correspondence with beginning or advanced astronomers (ages 13-18) interested in astronomy and/or horses, gymnastics, science fiction, and reading. Also, info. on astronomy clubs in S. Calif. Contact Jennifer Crum, 5132 Sepulveda, San Bernardino, CA 92407. Phone (714) 886-3186.

WANTED — Correspondence with men or women (ages 18-28), located in the southern regions, interested in exchanging astronomical photos and experiences, possible new club, please send three 18¢ stamps. Contact Francisco Gonzalez, 7175 Manor Rd., KC12, Columbus, GA 31907.

WANTED — Micrometer of either the cross-bar, filar or double-image type. (Double-image type preferred). Must be in good condition and capable of being used for serious double star work. Contact Robert Ingoglia, 120 Merselis Ave., Clifton, NJ 07011.

ASTRONOMY & SPACE SLIDES

*GALAXIES & NEBULAE	50 - $19.50
OBJECTS OF THE SOLAR SYSTEM	20 - $ 8.50
THE SUN/HISTORY OF A STAR	20 - $ 8.50
*SPECIAL - ALL 90 slides above	90 - $32.95
*APOLLO 11 Giant set in album	100 - $26.95
*APOLLO 12, 14, 15, 16, 17	80ea. - $23.95ea.
*EARTH FROM SPACE	25 - $ 9.75
MARINER 10 - Mercury & Venus	34 - $16.00
*MOUNT ST. HELEN'S ERUPTION	18 - $ 8.50
PIONEER VENUS	30 - $15.00
*U.S. NAVAL OBSERVATORY SLIDES	40 - $16.00
*VEHRENBERG'S Colorful Heavens	20 - $ 8.50
VIKING 1 - Landers on Mars	63 - $28.00
VIKING 2 - Landers on Mars	29 - $14.50
BEST VIKING - Mars	20 - $ 9.50
BEST VOYAGER 1 - JUPITER	20 - $ 9.50
BEST VOYAGER 2 - JUPITER	20 - $ 9.50
VOYAGER - JUPITER SPECIAL	100 - $29.95
BEST VOYAGER 1 - SATURN	20 - $ 9.50
VOYAGER 1 Saturn Encounter	40 - $16.95

Send 35¢ stamp for FREE slide catalog, all star charts, and films for astrophotography

ASTRO CARDS

P.O. Box 35, Natrona Heights, PA 15065

MEADE
QUANTUM
BUSHNELL
CELESTRON
ACCUTRACK
KALT CORP.
SWIFT INST.
VERNONSCOPE
SMITH-VICTOR
DAYSTAR FILTERS
EDMUND SCIENTIFIC
UNIVERSITY OPTICS

YOU CANNOT AFFORD TO BUY A
CELESTRON
Without Calling Us For The Most Competitive Prices To Be Found Anywhere.

96 pages of catalogs and manuals-$3 refund with first order. $5 foreign.

FREE PRICE LIST ON REQUEST.

Demonstrations by appointment, or call to discuss your specific needs.

OPTRON SYSTEMS
Eugene L. Cisneros
704 Charcot Avenue
San Jose, California 95131, U.S.A.
Phone: 408-946-4797 daytime
408-923-6800 evening

CELESTRON	
C90 Spotting Scope	$ 280
C5 Telescope	600
C8 Telescope	760
C11 Telescope	2450
C14 Telescope	5100
Wedge 5/8	50
Tripod 5/8/90	130
MEADE	
645 6″ f/5 with drive	450
826 8″ f/6 with drive	550
TOMLIN	
Light Weight Field Tripod. ***(ideal for Catadioptric Systems)***	65
Kellner Eyepieces f.1. 6, 12, 25, & 40 mm	18

OTHER ITEMS

Binoculars, Telescope Tubes & Mounts, Colored Slides & Murals, Mirror Cells, etc.

ASK ABOUT THIS MONTH'S SPECIAL OFFER!!!

Free shipping in continental United States

Personal checks allow 2-4 weeks to clear. California residents add 6% sales tax. All shipments made upon acceptance of your order. 52 page Meade General Catalog and 32 page Celestron Catalog. . . . $4.50 ppd.

Tomlin Enterprises
Showroom 4565 Industrial St., Suite 7H
Mail orders 1036 Stanford Dr., Dept. A
Simi Valley, California 93065 (805) 522-6646

8″ Deep Sky Telescope

$295
Shipping USA $12.50
Optional Mount $95 extra

SKY RESEARCH
BUILDS WORLDS LOWEST-PRICED 8″ TELESCOPES

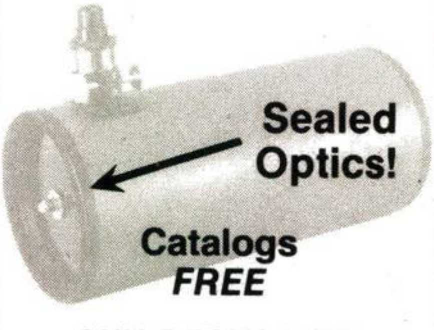
Cassegrains, Maksutovs

Brilliant Images
• **Super Fast Optics** •
Visual-Photo

Compact and Portable only 21″ long!
• 13 lbs. •

CONVERTS TO CASSEGRAIN with Kit $266.90

Big Low Profile 2.0″ Focuser



SKY RESEARCH
P.O. Box 2778
Santa Cruz, CA 95063
(408) 423-3275

Free!

Edmund Scientific Catalog

OUR 40th YEAR!

Astronomy, Microscopy, Biofeedback, Weather, Alternate Energy, Binoculars, Optics, Magnets, Magnifiers, Tools, Unique Lighting, Lab Equipment, and much more. Over 4,000 unique and fascinating products. Send for our **FREE** 112-page, colorful 1981 Edmund Scientific Catalog. . .Today!

Rush me your free catalog!

Name

Address

City

State Zip

Clip And Mail Coupon Today To:
Edmund Scientific Co., Dept. 3016 K-10
Edscorp Bldg., Barrington, N.J. 08007

No. 226 ©1981 Edmund Scientific Co.

ANNOUNCEMENT — Paris Astronomy Club now forming. You've been alone in the dark too long. Contact Chuck Goodwin, Rt. 2, Box 100, Paris, TX 75460. ATM's welcome if you keep your grits to yourselves.

ANNOUNCEMENT — Nonprofit astronomy correspondence club and monthly newsletter; exchange information, ideas, addresses, correspondence, activities; membership includes both individuals and clubs; articles and submissions about you welcome; $6 per year covers postage, handling. Contact Hello Out There, 1575 N., 650 W., Orem, UT 84102.

WANTED — Any 8" x 10" NASA space colonies colored pictures; also, the one that has an agriculture level. Will pay $2 apiece for them. Contact David Spiek, 556 E. Loula, Olathe, KS 66061.

WANTED — Generous and understanding individual to sell used 8" to 10" reflector at very low price to a financially struggling young astronomer. Mirror and tube assembly would be all right. Contact David Haney, 3337 W. Edge Rd., Topeka, KS 66605.

WANTED — Line printer for a computer, must be $200 or less. Also, looking for mini-disk drive (external) for $250 or less, and a telephone interface for $100. Contact George King III, Old Country Rd. W., Enfield, ME 04493.

WANTED — Correspondence with any professional astronomer, or anyone knowing what it takes to be one. I'm 16-years-old and wish to be a professional astronomer. Any information regarding universities, reading materials, etc., would be appreciated very much. Contact Brian Benson, 407 E. Pine, Cadillac, MI 49601. Phone (616) 775-9250.

WANTED — Astrophoto contest participants. $500 in gold guaranteed as 1st prize for best amateur astro photo or color slide. All prizes paid in precious metal. For rules and details contact Fred R. Brown, MGWT, 505 W. Park, Butte, MT 59701.

WANTED — Fork mount, wedge and tripod for C-8 or similar instrument, will pay up to $400. Contact J.B. Strong, 7415 Royalty Way #207A, Merriam, KS 66203.

FOR SALE or TRADE — Meade (model 826) R.A. and Dec. controls, 3 ortho eyepieces, illuminated reticle eyepiece, dustcaps, 2x Barlow, right angle finder, polaroid astrocamera back, $600 or trade for Dobsonian mirror. Contact R. Bateman, P.O. Box 517, Downieville, CA 95936.

FOR SALE or TRADE — 10 boxed Avalon Hill wargames, 2 dozen wargame magazine, 1/2 with games, several large SPI wargames, $80, or trade for any telescopic accessories. Contact R. Bateman, P.O. Box 517, Downieville, CA 95936. Phone (916) 289-3624.

FOR SALE — Criterion RV-6 reflector, used only once, 9mm and 18mm eyepieces, clock drive, equilateral mount, setting circles, dust covers, mint condition, $200. Will deliver within 50 miles. Contact Jon Ferrans, 6029 Blodgett Ave., Downers Grove, IL 60516. Phone (312) 969-5267.

FOR SALE — 6" mirror f/8, 6" mirror mount, diagonal mirror, spider mirror mount, focusing mount, 9mm eyepiece, 2x Barlow lens, 1 year old, very good condition, package deal, $75. Contact John Messer, P.O. Box 14, Petoskey, MI 49770.

FOR SALE or TRADE — 4" f/5 RFT with slide focuser, low-power eyepiece and 8x finder, $50. Will trade for 8" Celestron tripod. Contact John Messer, P.O. Box 14, Petoskey, MI 49770.

FOR SALE — Complete set of ASTRONOMY back issues: August 1973 through September 1980, mint condition, $150 plus shipping. Contact Helene F. Pinel, Box 269, Brooksville, ME 04617.

FOR SALE — Meade 40mm MA wide-field eyepiece, $20. Also, Celestron telecompressor, $25, all excellent condition. Contact Tom Polakis, 1535 6th St. Muskegon, MI 49441. Phone (616) 726-5526.

NEW! COMPUTATIONAL SPHERICAL ASTRONOMY by L.G. Taff $28.95
BURNHAM'S CELESTIAL HANDBOOK, VOL I, VOL II, VOL III-EACH . . . . $ 8.95
NEW! DAYTIME STAR-THE STORY OF OUR SUN by S. Mitton $14.95
NEW! OUT OF THE DARKNESS, THE PLANET PLUTO by C. W. Tombaugh & P. Moore $14.95
NEW! AAVSO STAR ATLAS $39.95
NEW! AMATEUR ASTRONOMERS HANDBOOK by J. B. Sidgwick, hard cover edition $24.95
soft cover edition . . . . . . $ 7.95
NEW! OBSERVATIONAL ASTRONOMY FOR AMATEURS by J. B. Sidgwick, soft cover . . . $ 6.50
NEW! COSMOS by C. Sagan $19.95
AMATEUR TELESCOPE MAKING, 3 Vols . . $35.00
NORTON'S STAR ATLAS $18.95
NEW! FIREBALLS, METEORS, AND METEORITES by H. Povenmire $10.95
NEW! THE TELESCOPE by L. Bell, reprint . . $ 6.50

Write for NEW enlarged free list of astronomical literature

Herbert A. Luft
P.O. BOX 91, OAKLAND GARDENS, NY 11364

ECLIPSE CHASERS!

Moonshadow Expeditions

Moonshadow Expeditions offers you an unique opportunity: observe the 1981 total solar eclipse in the afternoon of the day before it starts! Yes, that's right! Through the miracles of modern geography and the international dateline: you can be the last to see it first! . . . Or is it — the first to see it last? **But, come with us and see it** — with no interference from clouds — at 37,000 feet in a specially refitted DC 9-80.

Moonshadow Expeditions is the only domestic expedition to the 1981 total solar eclipse. We also offer:

- 10 days, 9 nights in beautiful Hawaii
- Optional tours of Mauna Kea and Haleakala observatories

This is the most economical eclipse expedition of 1981, at about half the average cost of other expeditions. Total price, including round trip air fare from L.A., hotels, and inter-island transfers: $1250 per person, double occupancy.

For further information write or call:

MOONSHADOW EXPEDITIONS
c/o NELSON'S TRAVEL, INC.
200 EAST ROWLAND AVE. • COVINA, CA 91723 • (213) 331-4864

TEXAS NAUTICAL REPAIR CO.

Sales and Service for telescopes, binoculars, microscopes, and other optical equipment.

In the last 30 years we've grown to be the largest dealer in the Southwest.

Call or stop by our showroom for products by Bausch and Lomb, Bushnell, Celestron, Clave', Edmund, Fujinon, Leitz, Meade, Nikon, Orion, Sky Publishing, Swift, University Optics, and Zeiss.

3209 Milam, Houston, Texas 77006
(713) 529-3551

BOWL OF NIGHT

This revolutionary sky simulator is virtually a hand planetarium which helps anyone understand the sky and locate stars easily. Aside from its unique capabilities and versatility, the BOWL OF NIGHT's eye-catching beauty makes it a perfect gift.

Made of high impact plastic, the BOWL OF NIGHT is 14" in diameter and weighs less than 3 pounds.

To order, send check or money order for $59.95 + $3 for shipping.

GL ENTERPRISES
185 Main St., Port Washington, N.Y. 11050

SUMMER SALE!

Great savings now from the world's leading independent telescope dealer!

Meade **Celestron** **Edmund**

Summer's a great time to spend time outdoors—and Orion is offering big Summer Sale savings on all sorts of telescopes and accessories to make your summer more enjoyable.

Orion is the fast, friendly place to shop. Our knowledgeable, helpful people can answer all your questions, whether you're a beginner or an "old hand" at stargazing.

Don't miss out on great summer viewing! Call or write for complete information on Orion's Summer Sale now!

AccuTrack MiniDrive

AccuTrack MiniDrive

12-volt power converter and variable-speed Drive Speed Control. Fast & slow override pushbuttons.

regular $69.95

$49

Tripod Tray for C-8

All aluminum tray with 1¼-inch holes for eyepieces, etc. Room for other accessories, too.
regular $39.95

$33

Accessories for C-8

Knob Set	reg. 11.95	SALE $ 9
Sun/Moon filter	44.95	$39
Polar Alignment Adjuster	19.95	$15
Tripod Bag	29.95	$20

Setting-Circle Lights for C-8

Our great new illuminator mounts in seconds, quality aluminum construction, uses inexpensive penlite cells.

$29.95

introductory price.

DO YOU HAVE YOURS?
36 pages full of hundreds of great telescopes, eyepieces, star charts, books, astrophoto equipment, Astronomer's lights, AccuTrack electronic controls, and much more!

Only $1.00
($3.00 foreign).

Get yours today!

ORION
1981
Catalog

ORION
TELESCOPE CENTER

mailing address:
P.O. Box 1158-A
Santa Cruz, CA 95061
U.S.A.

store & offices:
2215 41st Avenue
Capitola, Calif.

(408) 476-8715

OUR GUARANTEE

If you're not happy with any mail-order purchase, just return it in new condition within 30 days after received for a prompt, full refund. You be the judge!

ORDERING INFORMATION

$1.00 service charge on all orders under $15. Calif. residents add 6% tax. If you send check or money order, we pay shipping in continental USA (AK and HI extra). Shipping added to credit card and COD orders. Outside USA, shipping extra—please write before ordering. Phone orders welcome!

close-up on ophiuchus

through the eyepiece

Mercury

During July, Mercury will emerge from the Sun's glare into the morning sky, reach greatest elongation on the 14th, and swing back toward the Sun again. Since Mercury passes through perihelion on July 31, it is moving very fast in its orbit late in the month.

Anyone who follows Mercury with a telescope will get a fine view of its phases as they shift from crescent to half-lit to gibbous. Although this elongation is fairly good (21°), the planet will be hard to see because the ecliptic makes a shallow angle with mid-northern latitude horizons, and Mercury lies south of it.

On the morning of the 26th, Mercury will lie about 13′ of arc away from the 3.5 magnitude star, Delta (δ) Geminorum.

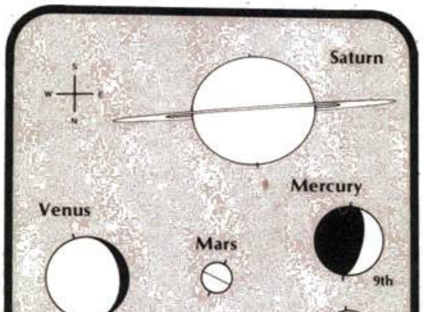
Mercury's elevation will be at its highest on the mornings of the 13th through the 24th, but even then it will be scarcely more than 6° high in the east-northeast, 45 minutes before sunrise.

Observers have two alternatives in the case of poor visibility: forget about seeing the planet until a better elongation comes along, or look for it in daylight. If you follow the latter course, offset from some known object such as the Sun. Look up the coordinates of the Sun and Mercury (use the planetary data table on page 80 or check the *Astronomical Almanac*) and find the difference between them in both right ascension and declination.

At this point, a properly aligned equatorial mounting will be a great help. Just center the Sun (by projection, NOT by looking into the eyepiece!) and offset the requisite amounts.

On March 13, 1976, Comet West was near the stars of Delphinus when Jack Zeiders photographed it. The comet's gas tail extends to the upper right while the dust tail goes straight up. Zeiders used a 135 mm lens at f/2.8, 103a-E film, and a 10 minute exposure. This wins the "Best Astro-Photo" award for July.

Searching with an alt/az mounting is more difficult. You'll find both a wide-field finder scope and a low-power eyepiece essential. (With both of these, work out the diameter of their fields of view ahead of time.) It will help to wait until around local noon to do your offsetting. And expect to do a bit of scanning when you've found the right area. After you find Mercury, use a red filter to suppress the bright blue sky and bring up the planet by contrast.



Despite all their challenges to your observing skills, Mercury's here-and-gone appearances can be a nuisance. In 1686 an English writer was provoked enough to label the planet "a squirting lacquey of the Sun, who seldom shows his head in these parts, as if he were in debt!"

Venus

Venus, too, is low in the murk of the horizon (though evening in this case), and, as the diagram last month showed, will remain there for several months more. At least it's bright enough to be easily found.

But anyone who wants to see the planet without looking through a thick layer of hazy, "boiling" atmosphere would do well to take a tip from the Mercury watchers and look for it during the daytime. Use the same technique: offset from the Sun and try a red filter to darken the sky — or a blue one to catch some faint markings on the cloud-tops.

On the evening of the 3rd, look for Venus just 29″ of arc to the north of Eta (η) Cancri, a 5.3 magnitude star. A day later, Venus will be to the east of M-44, the Beehive Cluster.

Moon

The Moon is the star actor at two events this month: a partial lunar eclipse on the 17th and a total solar eclipse on the 31st. But since these events are so special, we are featuring them in this month's Gazer's Gazette.

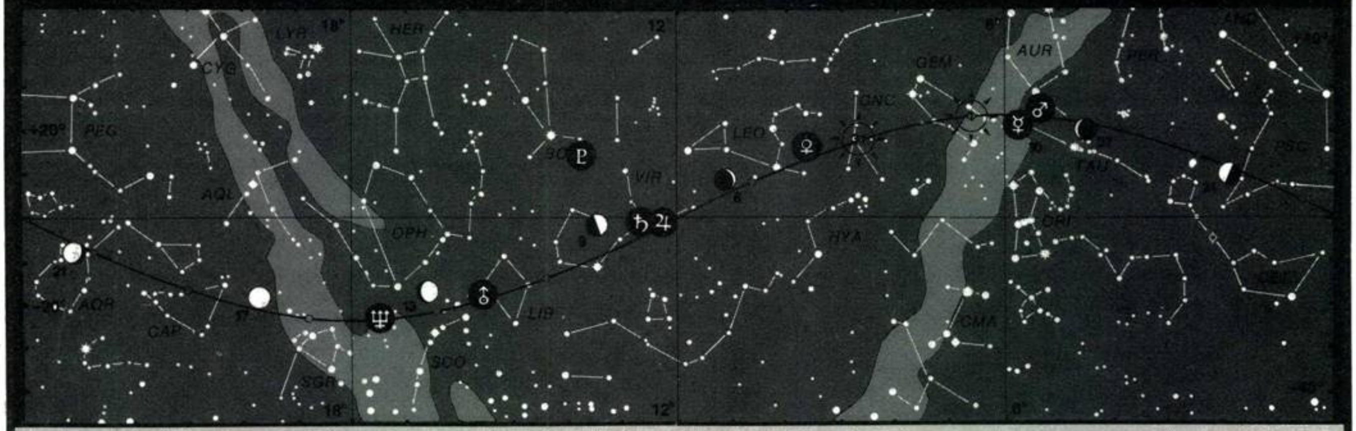
Mars

Mars progresses steadily eastward along the ecliptic during July at a rate of about 3m of right ascension per day. At this point, it is passing over the "hump" of the ecliptic (the northernmost limit) in Taurus and Gemini.

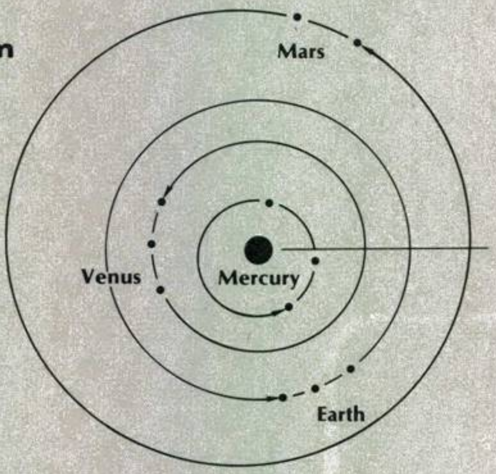
Forty-five minutes before sunrise on July 1, Mars will be just 7½° high in the east-northeast. On the morning of the 15th, when Mars has risen to almost 12° elevation, Mercury will lie 5° below it. By the 28th, a very thin crescent Moon (27 days old) to the lower right of Mars will be poised to overtake it. At month's end, Mars will be 17° high and easy to see.

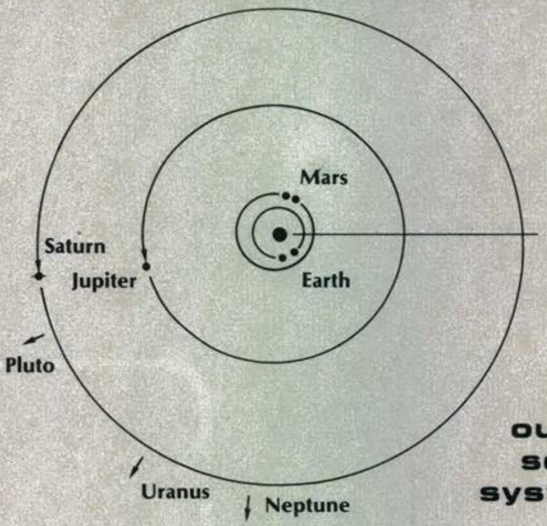
Unfortunately, as the planetary data table shows, Mars' apparent diameter

planetary data july 1981


LYR
HER
CYG
PEG
AQL
OPH
BOO
VIR
LEO
CNC
GEM
AUR
PER
ARI
PSC
TAU
ORI
HYA
CMA
CET
AQR
CAP
SGR
SCO
LIB
18h
12h
6h
0h
+20°
-20°

inner solar system


Mars
Venus
Mercury
Earth


Mars
Saturn
Jupiter
Earth
Pluto
Uranus
Neptune

outer solar system

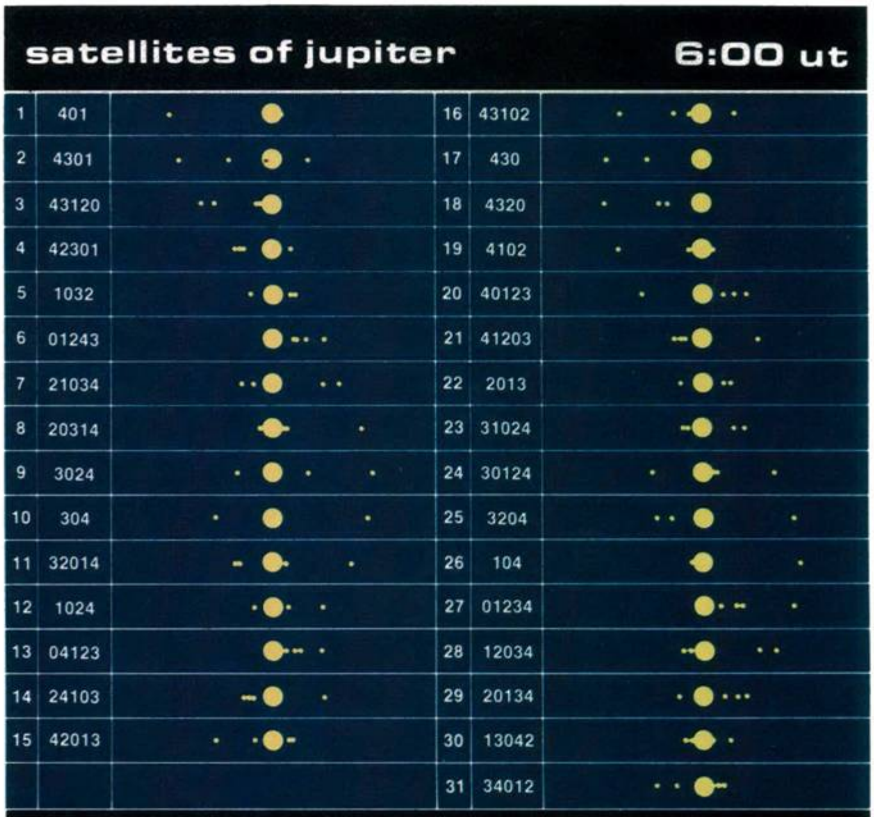
		Date	Mag.	Angular Size	% Illum.	Distance (AU) from:		Longitude:		R.A. (1981.5)	Dec
						Earth	Sun	Heliocentric	Ecliptic		
Sun		1	-26.7	31.5′	—	1.02	—	—	99°04.8′	6h 39.5m	+23°07.8′
		15	-26.7	31.5′	—	1.02	—	—	113°25.8′	7h 36.9m	+21°34.5′
		31	-26.7	31.6′	—	1.02	—	—	127°42.1′	8h 40.4m	+18°20.7′
Mercury	☿	1	+2.1	10.8″	8%	0.62	0.44	296°45.7′	86°20.5′	5h 45.6m	+18°44.4′
		15	+0.5	7.7″	38%	0.86	0.37	348°03.1′	91°25.2′	6h 07.9m	+20°49.9′
		31	-1.2	5.4″	88%	1.23	0.31	76°15.4′	116°03.8′	7h 54.5m	+21°40.8′
Venus	♀	10	-3.3	11.2″	90%	1.50	0.72	168°36.8′	76°46.1′	9h 01.1m	+18°39.4′
		31	-3.4	12.1″	86%	1.39	0.72	202°34.3′	101°59.9′	10h 39.8m	+9°59.4′
Mars	♂	15	+1.7	3.9″	98%	2.39	1.52	71°33.2′	199°08.6′	5h 50.0m	+23°51.9′
Jupiter	♃	15	-1.5	34.6″	99%	5.69	5.45	193°52.1′	210°27.8′	12h 15.5m	-0°19.3′
Saturn	♄	15	+1.2	16.9″	100%	9.86	9.59	190°05.5′	195°38.9′	12h 19.5m	+0°27.1′
Uranus	⛢	15	+5.8	3.8″	100%	18.24	18.82	238°48.1′	240°27.6′	15h 35.9m	-19°06.4′
Neptune	♆	15	+7.7	2.5″	100%	29.39	30.28	263°39.9′	264°31.9′	17h 28.6m	-21°53.2′
Pluto	♇	15	+14.0	—	100%	30.03	30.03	203°37.2′	203°44.8′	13h 45.3m	+7°28.1′

moon data

New Moon	July 1 at 19:03
First Quarter	July 9 at 02:39
Full Moon	July 17 at 04:39
Last Quarter	July 24 at 09:40
New Moon	July 31 at 03:52
First Quarter	August 7 at 19:26
Apogee: July 11, at 18h	404.838 km
Perigee: July 27 at 9h	367,265 km

universal time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times given in Through the Eyepiece are UT unless noted otherwise. To convert UT into your local daylight time, subtract the following number of hours for each time zone: EDT, 4; CDT, 5; MDT, 6; PDT, 7; Alaska, 9. For example, if an event is to happen at 03:00 hours UT on June 7, then EDT for the event is 11 p.m., June 6. Likewise, 03:00 UT on September 2 becomes, in PDT, 8 p.m., September 1.



Jupiter = 0, Io = 1, Europa = 2, Ganymede = 3, Callisto = 4
(South is at top, matching the view in a telescope)

is scarcely more than a tiny dot — and we'll have a long wait before it improves much.

Asteroids

1 Ceres (magnitude 8.3) is in eastern Leo. Positions:

10th: 9h 48m 52s, +21° 33.8′
20th: 10h 06m 09s, +20° 00.3′

Ceres sets around 10:30 p.m. local daylight time on the 15th.

2 Pallas is in conjunction with the Sun on July 21.

3 Juno (11.2) lies in Virgo, about halfway between Arcturus and Spica. Positions:

10th: 13h 43m 24s, +1° 10.6′
20th: 13h 48m 00s, +0° 24.9′

Juno sets at about 1 a.m. local daylight time at mid-month.

4 Vesta (7.9) will shift eastward from Leo into Virgo during July. At 0:23 UT on July 6, it will pass about 18′ of arc north of the 4th magnitude star Iota (ι) Leonis. Positions:

10th: 11h 28m 56s, +10° 11.9′
20th: 11h 44m 25s, +8° 16.8′

Vesta will set around 11:15 p.m. local daylight time on the 15th.

Jupiter and Saturn

On July 23, Jupiter will pass close to Saturn for the third time in seven months; the separation will be 1° 6′. A week later on the 30th, Jupiter's conjunction in right ascension with Saturn (distance 1° 12′) winds up the 1980/81 Triple Conjunction.

With both objects in the same low-power eyepiece field, it's fun to make some comparisons. For example, during the last week of July, Saturn lies some 4.175 astronomical units farther away from us than Jupiter. Or, to put it another way, Jupiter is a little over 58% the way to Saturn.

This distance difference, so easy to bridge with a telescope, puts Saturn 35 light-minutes deeper into space than Jupiter. You can't tell, of course, but the light you see from Saturn is fully an hour and 10 minutes older than that arriving from Jupiter.

This coincidence of distance also means that Saturn's ring system — which extends just less than twice Jupiter's equatorial diameter — appears to be about the same size as Jupiter.

Saturn, which in reality is just as reflective as Jupiter, appears over 2.5 magnitudes dimmer. Why? For two reasons: first, Saturn is slightly smaller — its reflecting surface (excluding the rings) is 71% of Jupiter's. Second and most important, Saturn lies much farther away from the Sun than Jupiter. The "inverse square" law of radiation — where doubling the distance quarters the brightness — drastically dilutes sunlight. (At Pluto's average orbit, sunlight is only 1/1600 that of what we on Earth receive.)

Uranus

Lying only a few minutes of arc to the west of the 5.5 magnitude star 41 Librae as July opens, Uranus will continue its slow west-northwesterly course. On August 4, it will halt and begin direct (eastward) motion.

Find the planet by centering your scope on 4th magnitude Theta (θ) Librae (marked on the Star Dome map) and then sweeping 4½° southwestward to magnitude 4.7 Kappa (κ) Librae. From Kappa, look a little over a degree to the west-northwest for Uranus' small greyish disk.

Neptune

Neptune is in the southern reaches of the constellation Ophiuchus (see Close-up this month), about 4° to the northeast of the 3rd magnitude star Theta (θ) Ophiuchi. Look for a tiny grey disk, 2.5″ of arc across.

Meteors

During the last week of July, the Delta (δ) Aquarid meteor shower reaches a broad peak of activity. Actually comprised of two streams, the "northern" and the "southern," the Delta Aquarids produce some 10 to 25 meteors per hour. Their radiant point lies near the star whose name they bear.

Another late July shower is the Capricornid. These come from the constellation of their name and usually have 10 to 15 meteors per hour.

You'll probably see more meteors late in the month because the Moon then will be closer to New (which is on July 31).

close-up on ophiuchus

If the zodiac had room for a 13th constellation, it surely ought to be Ophiuchus, the serpent-bearer. Few observers think of it as zodiacal because its brightest and most prominent stars lie well to the north of the ecliptic, but Ophiuchus plays "host" to the Sun longer than does its neighbor, zodiacal Scorpius!

Extending from approximately +15° declination down to -30°, and from about 16h right ascension eastward to 18h 40m, Ophiuchus divides the two parts of Serpens into the Caput (head) and Cauda (tail). It lies due west of the Milky Way constellation Aquila.

Because they are on the outskirts of the Milky Way, the starfields of Ophiuchus offer many fine sights for the telescope owner — as a glance at the list on page 85 will show. The only deep-sky objects conspicuously missing are galaxies — and you never find them near the obscuring dust and gassy haze of the Milky Way.

Let's start our tour in the north, at Ophiuchus' brightest star, 2.1 magnitude Alpha (α). Commonly known as Rasalhague (Arabic for "head of the serpent-charmer"), the star itself is of little telescopic interest and we will use it only as a convenient reference point.

First on our list this month is **IC-4665**,

NGC-246 is an 8th magnitude planetary nebula in Cetus that forms a neat equilateral triangle (measuring 1° 30′ on a side) with the two 5th magnitude stars Psi^1 (ψ^1) and Psi^2 (ψ^2) Ceti. Bill Iburg's photo was taken with a 14-inch telescope at f/5.5 on 400 ASA film exposed 40 minutes in a cold camera.

a large but sparse open cluster. IC-4665 lies 11m of R.A. east (2°45′) and nearly 7° south of Rasalhague. Or you may prefer to start at Beta (β) Ophiuchi, a 2.8 magnitude star about a degree and a half to the southwest of the cluster.

The cluster spreads out to fill a circle almost a degree across — use a low-power eyepiece and sweep slowly past it to get the best visual effect. With average instruments (6 to 8-inch) you'll see 15 to 20 member-stars. Combining the brightnesses of all of them in the cluster yields an integrated magnitude of about 6.

One of the most famous stars in modern astronomy is the dim red dwarf known as **Barnard's star**. This 9.5 magnitude star has the largest proper motion ever found, 10.3″ of arc per year almost due north, and is the second closest system to the Sun — only Alpha Centauri lies closer.

Look for it by centering your scope on Beta and then moving 14 minutes (3°30′) of R.A. east and 30′ north. Use the map on page 84 to help you locate the star.

Now go back to IC-4665, and scan a degree north and 26m of R.A. east (6°30′) to arrive at the planetary nebula, **NGC-6572**. Any telescope bigger then a 3-incher will reveal distinctly the bluish nebula glowing at magnitude 9.6. There's also a 12th magnitude central star, but this is visible only with a large instrument. Imperfectly round, the nebula measures about 16′ by 13′ of arc.

To many observers in the past, its blue color appeared unusually intense for a planetary nebula — most appear grey or grey-green. How do you see it?

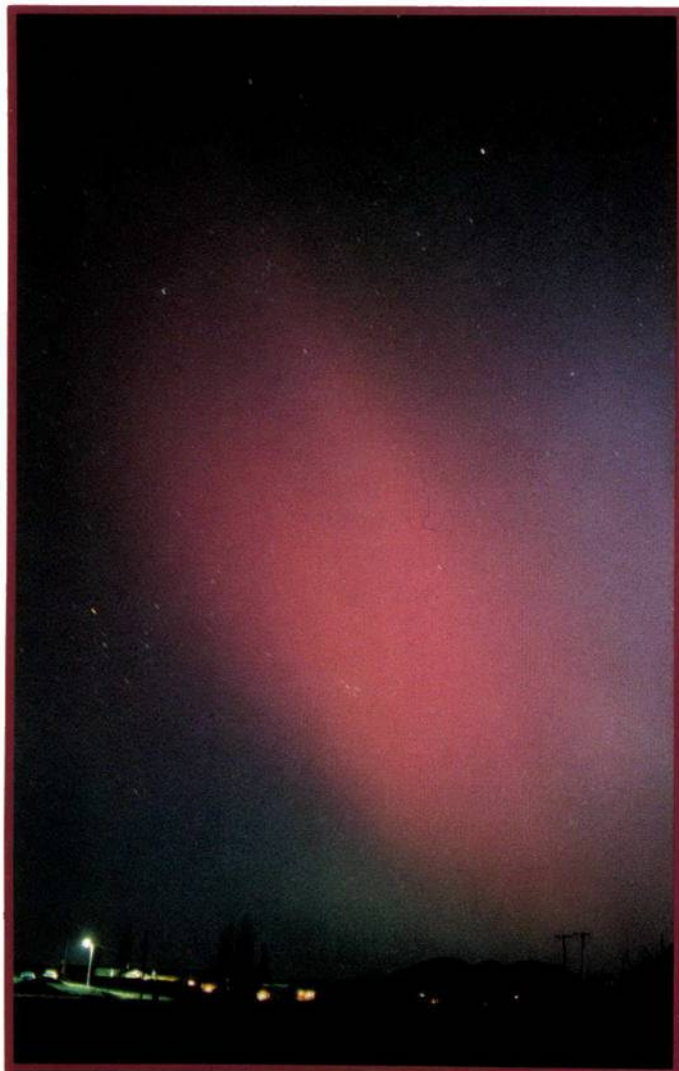
Fifteen minutes of R.A. east (3°45′) and some 18′ of arc south of this planetary lies a pretty open cluster, **NGC-6633**. A loose, 6th magnitude aggregation of about 30 stars, NGC-6633 lies in a fairly rich area and shows up as a denser knot of stars when you scan past it with low power. There's a 6th magnitude star about 15′ of arc to the southeast.

Midway between NGC-6633 and IC-4665 and about 3° south is an interesting 4.0 magnitude double star, **70 Ophiuchi**. 70 Oph marks the northeast corner of a south-pointing triangle of naked-eye stars. (The two other "corners" are 67 Oph and 68 Oph — of magnitudes 4.0 and 4.5, respectively.)

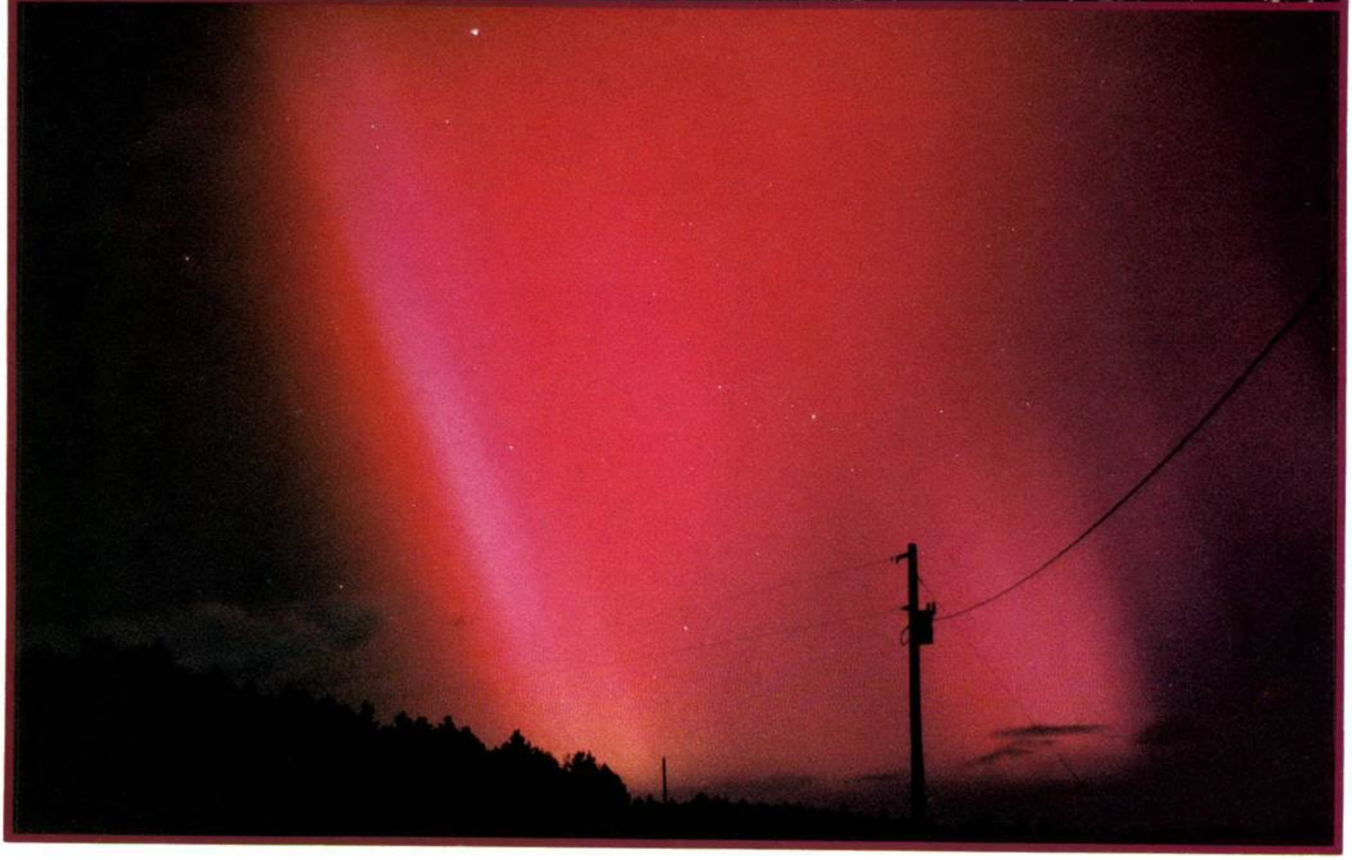
The 70 Ophiuchi system consists of two dwarf stars (magnitudes 4.2 and 5.9) in a 88 year orbit around their mutual center of gravity. The physical separation of the two components ranges between 12 and 35 astronomical units; the system lies about 17 light-years distant. (Careful studies of astrometric photographs have led some astronomers to propose that at least one unseen companion having about the mass of 10 Jupiters is also a part of the system.)

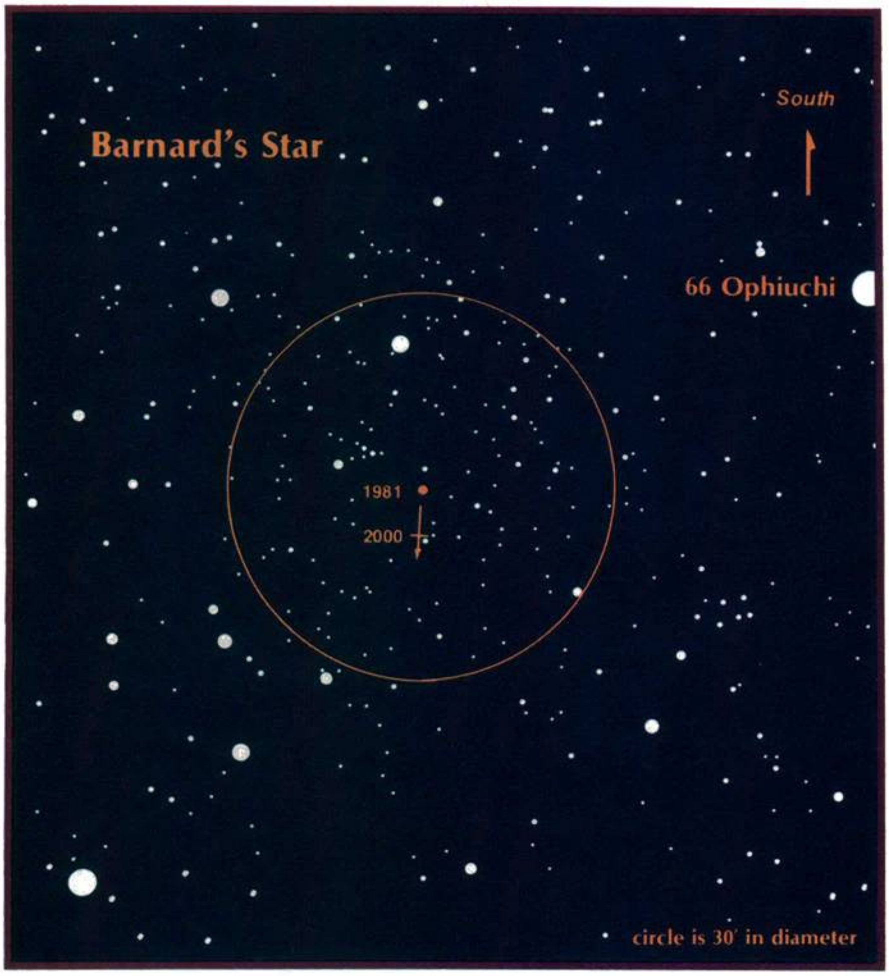
Several observers have noted a color difference between the two components. Rev. T. W. Webb saw them as yellow and orange, many others as yellow and red. But color estimates are notoriously tricky and the stars' spectral types (K0 and K6) should not produce such a marked difference as many claim. What's the answer? See for yourself, but try not to let what you know already bias your judgment.

At present the two components are near their minimum separation and moving relatively rapidly. This is one of



Aurorae have certainly been active in recent months! At left, the Pleiades, Hyades, and Auriga in Dan Ostergaard's photo of April 12. Above: Even low latitudes (35° N) saw the April 12th aurora. Photographer Devin McJoynt was at Young Harris, Georgia. Below: Sheldon Faworski's photograph was taken in March from northern Illinois. Bottom: Bright red streaks marked the April 12th event as seen by Alan Raycraft from Florissant, Colorado.





circle is 30′ in diameter

the few bright binary systems for which orbital-position changes are obvious over the short span of a few years. Currently about 2″ of arc to the northwest of the primary, 70 Oph B will be moving mostly southward relative to the brighter 70 Oph A during the next decade.

To find our next object, let's return to our starting point. Center Rasalhague in a low-power eyepiece and scan first 2 minutes of R.A. east (30′) and then fully 15°45′ south. Through the center of your field of view will pass the globular cluster **M-14**.

Discovered by French comet-hunter Charles Messier in the late spring of 1764, this 8th magnitude cluster appears small (6′ of arc), faint, and round; the central parts seem fairly condensed. Those observing with average-size instruments will be able to discern a graininess that resolves into stars at moments of excellent seeing.

Now center M-14 and sweep 40m of r.a. westward (10°), then 49′ of arc south to locate another globular, **M-10**. M-10, brighter and larger than M-14, is a fine sight — even a small instrument will give a good view. Its slightly oval shape has a diameter of about 12′ of arc.

A sample of past eyepiece impressions: John Herschel, "a fine large cluster. . .with stragglers"; Smyth, "a rich globular of compressed stars. . .attenuated at the margin and clustering to a blaze at the center"; Webb, "a beautiful group."

Three degrees to the northwest of M-10 lies a second globular almost as fine — **M-12.** Not as well concentrated in appearance as M-10 and slightly dimmer (magnitude 6.9), M-12 has about the same angular size (12′ of arc).

In appearance, the cluster has the typically condensed look common to almost every globular. In average instruments on nights when the atmosphere is very steady, globular clusters often hover on the verge of resolving into stars. This can produce a slow-moving granularity that makes the cluster look very much like a swarm of luminous bees!

Rasalhague lies too far away to be a starting point for exploring the southern parts of Ophiuchus, but Antares, Scorpius' bright red eye, is perfectly located. Center your eyepiece on it (and, no, it won't hurt to linger a few minutes to look at its ruddy blaze) and then sweep eastward 33m of R.A. (8°15′) and north about 8′ of arc to find the small globular cluster **M-19**.

With an apparent diameter of about 5′ of arc and a total brightness of 6.8 magnitude, M-19 is not as outstanding as the three globulars we've examined so far. Its outer edges resolve fairly easily into stars and it has a distinctly oblate shape — in fact, it's one of the most oval of all globulars.

Two minutes of R.A. west (30′) and almost 4° south from M-19 lies another small globular, **M-62**. About 6.5 magnitude and with a diameter of about 6′ of arc, M-62 looks basically round in small instruments — though larger apertures will bring out strongly the cluster's asymmetry. The clearly visible central nucleus is displaced to the southeast and gives it a cometary appearance.

To find our next object, let's go back to M-19 and then star-hop along a short curving trail to the little globular cluster **M-9**. About 5 degrees to the east-northeast of M-19 lies 3rd magnitude Theta (θ) Ophiuchi and 4° to the north-northeast of Theta is Xi (ξ) Ophiuchi. Xi lies 2¾° south and a little east of M-9. (Just for fun, take a look about 2¼° to the southeast of Xi. That small greyish dot, 2.5″ in diameter, is the planet Neptune!)

Most observers agree fairly well on M-9's brightness (magnitude 7.5 to 8), but everyone estimates its size differently — some say about 3′ of arc, others range from there up to 8′. A lot depends on aperture, sky transparency, and whether or not you use averted vision. In any case, the cluster looks like a small bright core with a surrounding dim halo. Smyth said it was "wonderfully aggregated with numerous outliers seen by glimpses." What do you see?

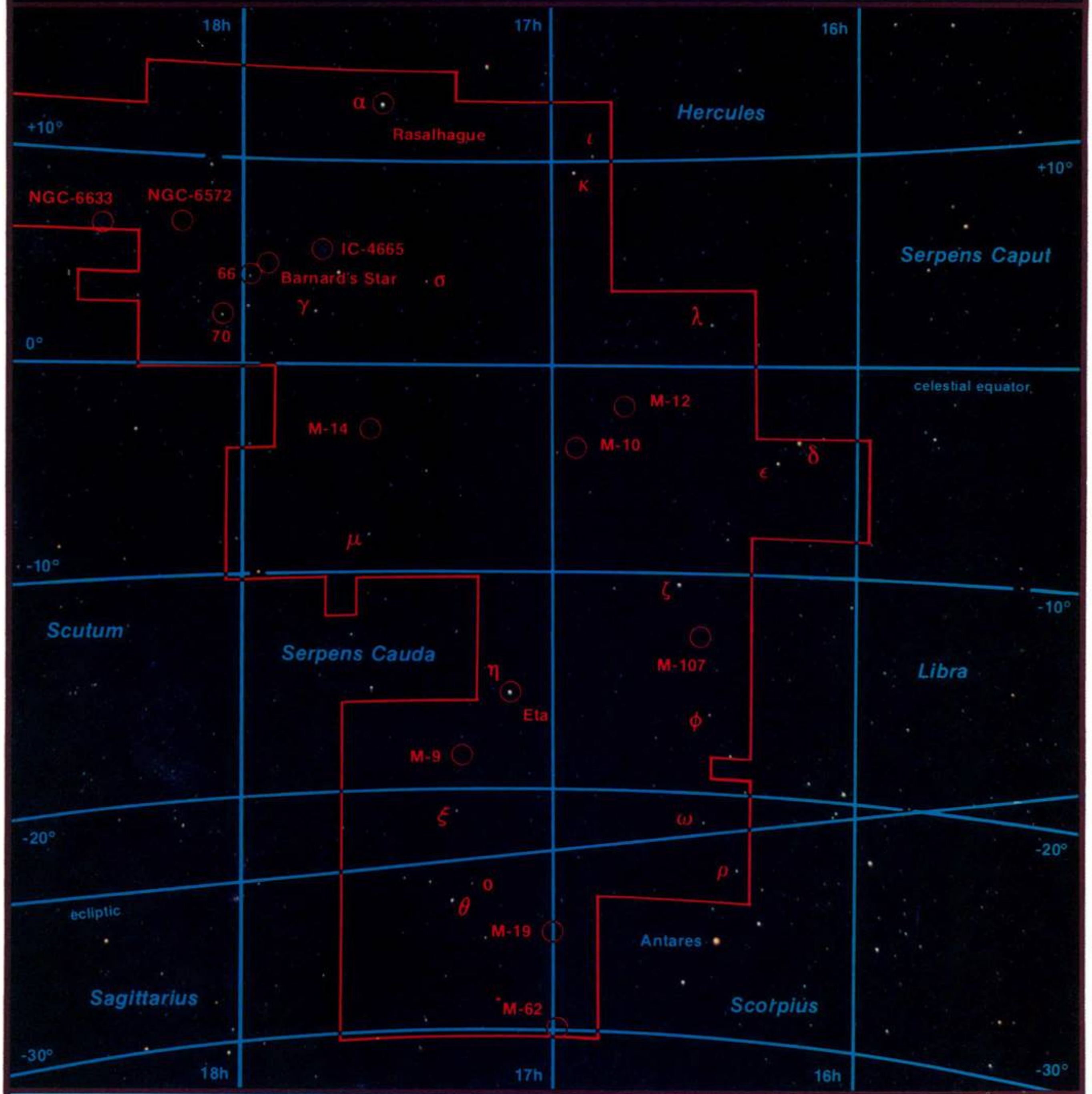
Three and a half degrees to the northwest of M-9 gleams a naked-eye star, **Eta (η) Ophiuchi**, that's also a close double. Integrated magnitude for the two components adds to 2.5; the components are of 2.9 and 3.4 magnitudes respectively. The spectral type for the pair is A2 and it's likely both stars are closely similar. Robert Burnham Jr. (in his *Celestial Handbook*) notes that we are seeing the system nearly edge-on — only 7° inclined to the line of sight, and that periastron will occur in 2020. The period of the system is 84 years. Splitting this double is a good challenge for anyone with a large instrument!

Our last object this month will be another globular cluster, one of the "addenda" Messier objects — **M-107**. An 8th magnitude hazy spot about 8′ of arc in diameter, M-107 is pretty dim. In small instruments, you'll see a faint glow that looks a lot better with averted vision. Larger instruments will show more, and under good conditions, resolve stars across the cluster's face.

photo by Brad Wallis & Robert Provin

ophiuchus

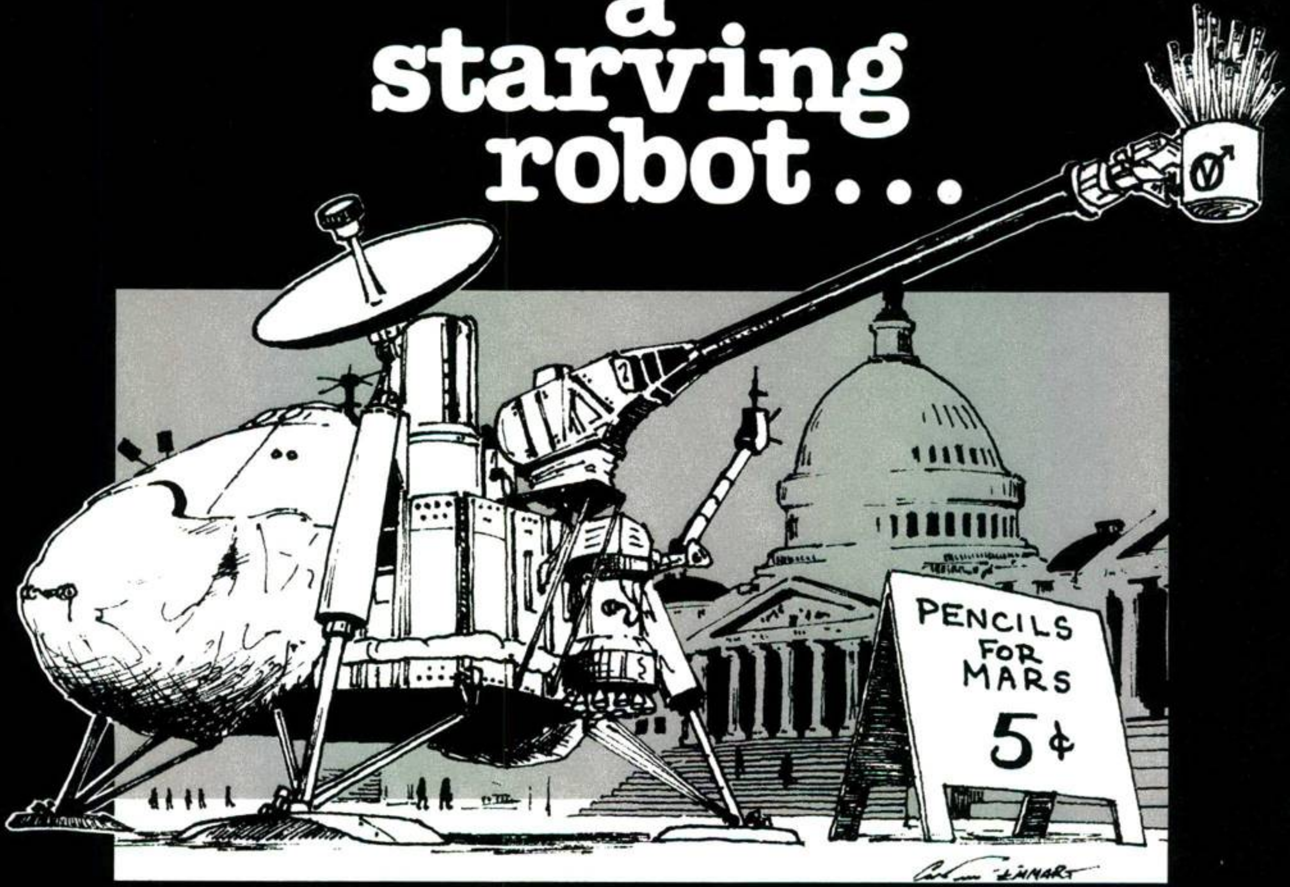
map by Robert Burnham


18h
17h
16h
+10°
0°
-10°
-20°
-30°
Hercules
α
Rasalhague
ι
κ
NGC-6633
NGC-6572
IC-4665
66
Barnard's Star
σ
γ
70
Serpens Caput
λ
celestial equator
M-12
M-14
M-10
ε
δ
μ
ζ
Scutum
Serpens Cauda
M-107
η
Eta
Libra
φ
M-9
ξ
ω
ecliptic
ρ
o
θ
M-19
Antares
Sagittarius
M-62
Scorpius

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950) Dec.		R.A. (1981) Dec.	
M-107	●	8.2	8′	16h30m	-12°57′	16h31m	-13°01′
M-12	●	6.9	12′	16h45m	- 1°52′	16h46m	- 1°55′
M-10	●	6.6	12′	16h55m	- 4°02′	16h56m	- 4°05′
M-62	●	6.5	6′	16h58m	-30°03′	17h00m	-30°06′
M-19	●	6.8	5′	17h00m	-26°11′	17h01m	-26°14′
Eta (η)	★^{2}	2.9,3.4	1″	17h08m	-15°40′	17h09m	-15°42′
M-9	●	7.8	6′	17h16m	-18°28′	17h18m	-18°30′
M-14	●	7.5	6′	17h35m	- 3°13′	17h37m	- 3°14′
IC-4665	○	5.9	55′	17h44m	+ 5°44′	17h45m	+ 5°43′
Barnard's Star	★	9.5	—	17h55m	+ 4°24′	17h57m	+ 4°24′
70 Ophiuchi	★^{2}	4.2,5.9	2″	18h03m	+ 2°31′	18h04m	+ 2°31′
NGC-6572	■	9.6	16″x14″	18h10m	+ 6°50′	18h11m	+ 6°50′
NGC-6633	○	6.0	20′	18h25m	+ 6°32′	18h27m	+ 6°33′

★	*Star*
★^{2}	*Double Star*
★^{3}	*Triple Star*
ⅿ★	*Regular Variable*
∩★	*Irregular Variable*
Ӿ★	*Eclipsing Variable*
○	*Open Cluster*
●	*Globular Cluster*
■	*Planetary Nebula*
□	*Bright Diffuse Nebula*
§0	*Elliptical Galaxy*
§S	*Spiral Galaxy*
§ʃ	*Barred Spiral Galaxy*
§#	*Peculiar/Irregular Galaxy*

Feed a starving robot...



...and a starving space program.

Despite growing public support, our space program is dying. Every week a new pro-space group forms. Millions avidly watch as NASA's probes scout the endless frontier. Many more pay to see space dramas like **Star Wars** and **Close Encounters.**

Yet the politicians starve NASA. Programs that explore our universe, strengthen our economy, and improve our lives are delayed, deferred, defeated. Why? The budget cutters don't think we care about our space program. They see NASA's funding as a painless place to trim the budget.

Last year, 8,000 people dug into their pockets to feed a starving robot—the Viking lander on Mars. They contributed to the Viking Fund, and today their money is helping to pay the costs of receiving and analyzing Viking's data. Their donations will help scientists better understand Mars and thereby our Earth.

For a few bucks, you too can explore Mars. Send your tax deductible contribution to the Viking Fund ($1 minimum), and you'll receive regular updates on the results made possible by your contribution. You'll be helping a starving robot and telling the politicians to start feeding our space program.

THE VIKING FUND Dept. A • 357 Saratoga Avenue • Santa Clara, CA 95050

Look Into The Dynamax Schmidt-Cassegrain Telescope. See What You're Missing.

If you have yet to look into the Dynamax Schmidt-Cassegrain telescope, we strongly urge you to do so.

Because until you do, here's what you'll be missing:

A Schmidt-Cassegrain system with oversized primary mirror and Schmidt-plate-only image correction. To give you full-field illumination as well as the greatest possible freedom from aberrations and color imbalance off axis.

Diffraction-limited optics so smooth of overall figure that the quality of the total system exceeds even professional demands.

A galaxy of added-performance features not available with any other Schmidt-Cassegrain of comparable size.

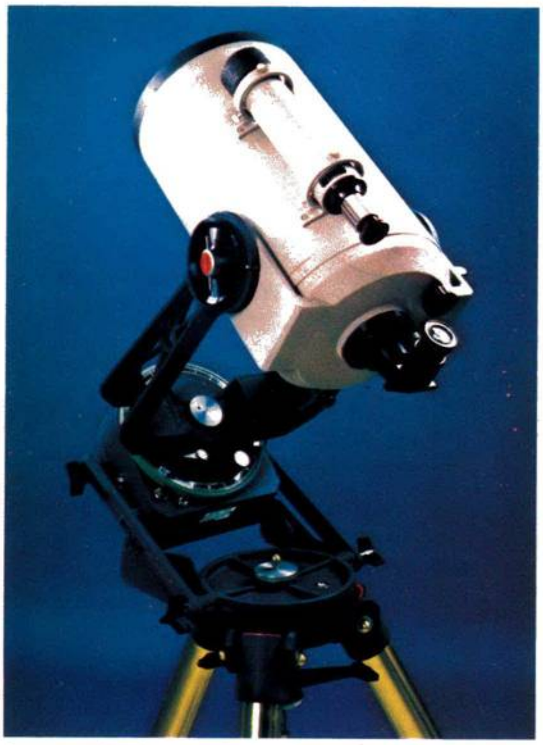
Like expansion-proof, non-conducting, oversized tube, for total dimensional and thermal stability—a tube that won't expand or contract like aluminum—a tube so strong the military fires rockets from it.

Like rugged *sand-cast* aluminum construction; inside-stress-cantilever fork arms; heavy-duty, self-centering polar ball bearings; fully enclosed clock-drive system.

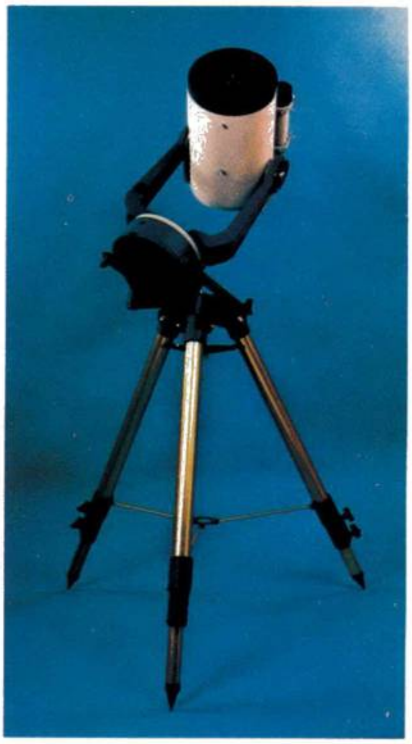
Like radially adjustable R.A. slow-motion control, dual-knob Dec. slow-motion control, setting circles readable from the observer's position, multipurpose R.A. setting circle.

And there's more.

We talk about it in our new 16-page color catalog, which features photos taken through the Dynamax. The catalog is yours for the asking. Write for it today.



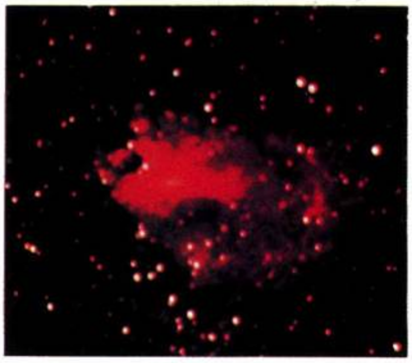
Rear view of the Dynamax 8 mounted on Dynamax Field Tripod



Front view of the Dynamax 8 mounted on field tripod

Dynamax Price Increase

Due to the tremendous response to our recent price announcement we are extending the present price to orders postmarked prior to June 15, 1981. Effective June 15, the price will be increased to $949.95.



The Omega Nebula (M17) as photographed through the Dynamax 8.

DYNAMAX®
Worth Looking Into

CSi

Write or Telephone For Free Color Catalog
CRITERION SCIENTIFIC INSTRUMENTS
Dept. ASC-16 620 Oakwood Avenue • West Hartford, CT 06110
Telephone (203) 247-1696

In New York:
Robert T. Little
Field Sales Manager
212-834-1888

In Florida:
William Douglass
305-667-9066

In Chicago:
Jim Michaelsen
312-879-0629

In California:
Robert Campbell
213-347-3388

Celestron®

The world's most complete systems
for astronomy or telephotography

For a completely updated new 52 - page catalog on all Celestron products, please send $3.00 to: Celestron International, 2835 Columbia St. Box 3578-B Torrance, CA 90503 (213) 328-9560